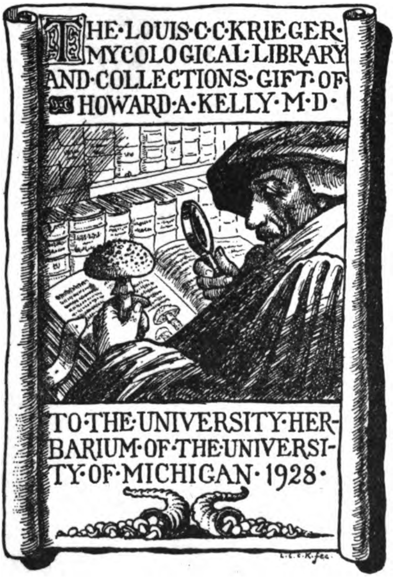
Phyto-theology

John Hutton Balfour

H. A. KELLY, M. D.


THE·LOUIS·C·C·KRIEGER·
MYCOLOGICAL·LIBRARY
AND·COLLECTIONS·GIFT·OF
HOWARD·A·KELLY·M·D·
TO·THE·UNIVERSITY·HER-
BARIUM·OF·THE·UNIVERSI-
TY·OF·MICHIGAN·1928·
L·C·C·K·fec·

Late Prof of Botany in Edinburgh, his Son is the present professors
There were four brothers, all eminent Christian men.

This is the original edition. There were further editions under the title: Botany and Religion.
(L.C.C.K.)

Awarded to
Miss Robina Macfarlane,
2nd Prize
Botanical Class,
(3rd division)
Edinburgh Institution
23 Charlotte Sqre
July 1853.

Thomas Oliphant.

PHYTO-THEOLOGY;

OR,

BOTANICAL SKETCHES,

INTENDED TO ILLUSTRATE

THE WORKS OF GOD

IN THE

STRUCTURE, FUNCTIONS, AND GENERAL DISTRIBUTION
OF PLANTS.

BY
JOHN HUTTON BALFOUR,
M.D., F.L.S., F.R.S.E.,
PROFESSOR OF MEDICINE AND BOTANY IN THE UNIVERSITY OF EDINBURGH.

Second Edition.

JOHNSTONE & HUNTER,
LONDON AND EDINBURGH.

M.DCCC.LI.

EDINBURGH :
PRINTED BY JOHNSTONE AND HUNTER,
104 HIGH STREET.

TO THE

REVEREND D. T. K. DRUMMOND, B.A.,

INCUMBENT OF ST THOMAS'S ENGLISH EPISCOPAL CHAPEL, EDINBURGH.

My Dear Friend,—It is to me a source of peculiar pleasure to be permitted to dedicate this little work to you. There is no one to whom I could do so with higher satisfaction, whether I take into account the deep obligations under which I lie to you, in the providence of God, as a faithful minister of the gospel, or the affection which I entertain towards you as an esteemed and valued friend.

You have often encouraged me to undertake such a work as the present, and have pressed upon me the importance of prosecuting science in a Bible spirit. During the occasional botanical walks, in which we have taken sweet counsel together, your Scriptural views of science have been impressed upon my mind; and I hope, in the short sketches

which are now placed before you, there is evidence that your kind suggestions have not been unheeded.

The sketches are very imperfect. They have been drawn up at a time when I had many other occupations to engage my attention; and they call for much indulgence. If they are blessed in any way in promoting the cause of Truth, I shall feel that my labour has not been in vain.

That you may be long spared to fill that useful station which you now occupy, and that you may be the honoured instrument, in the hand of God's Spirit, of proclaiming the Truth as it is in Jesus, and of turning many from darkness unto light, and from the power of Satan unto God, is the earnest prayer of,

Your affectionate friend,

J. H. BALFOUR.

PREFACE.

THE subjects embraced in the present volume formed the substance of introductory lectures on Botany, which I delivered on more than one occasion to a popular audience. The Rev. Dr King, who attended one of these courses of lectures, urged upon me the propriety of putting my notes into a state fit for publication; and when he undertook the first volume of the "Christian Athenæum," he kindly asked me to unite with him in forwarding the cause of religion and science by contributing a botanical volume. To this I was also stirred up by the advice tendered to me by the late Rev. Edward Bickersteth, who entered warmly into the plan of the work. Yielding to these solicitations, I undertook the task, and I feel that in doing so I have placed myself in a position of great responsibility. I am fully sensible of the imperfect nature of this attempt to illustrate the works of God in the economy of vegetation; but I trust that it may be the means of leading others to take an

interest in a science, in the prosecution of which I have spent many pleasant hours,—a science which does not consist, as many suppose, in the mere naming of plants, but which has a higher and a more philosophical aim.

I have endeavoured to add to the value of the work by giving numerous wood-cuts derived from the works of Maout, Jussieu, St Hilaire, Dutrochet, and others; and I have to acknowledge my obligations to the Messrs. Blackie, for allowing me to get impressions from some of the cuts of their Imperial Dictionary.

CONTENTS.

CHAPTER III.

CHIEF PASSAGES OF SCRIPTURE ILLUSTRATED.

LIST OF WOOD-CUTS.

---

* In the Note at page 33, this is called, by mistake, Dendrobium.

* In the Note at page 136, this is called, by mistake, Wallflower.

PHYTO-THEOLOGY;

OR,

BOTANY AND RELIGION.

INTRODUCTORY REMARKS.

1. THE attention of all who are interested in the wellbeing of mankind has been recently much directed to the subject of education. Schools of various kinds have been established, philosophical and mechanics' institutions have been formed, and men well versed in literature and science have eagerly availed themselves of the opportunities thus presented of diffusing information among the people. The poorest working man of the present day has thus within his power the means of acquiring knowledge. How important is it that such

knowledge should be solid and substantial,—not "science falsely so called, which some professsing, have erred concerning the faith" (1 Tim. vi. 20, 21), nor the "perverse disputings of men of corrupt minds and destitute of the truth" (1 Tim. vi. 5), who erroneously view reason as opposed to revelation. If the fountains are poisoned, it is not to be expected that those who drink at them will be sound and healthy. Instances are, it is to be feared, not uncommon of parties who, by the acquisition of unsanctified scientific information, have been led into the depths of infidelity and pantheism; making their very knowledge the means of perverting others, and of throwing ridicule and contempt on every thing relating to man's fallen condition, and God's glorious plan of salvation.

2. The question then is, How is education to be prosecuted, so as to promote the true welfare of the people? Undoubtedly this can only be accomplished by regarding man, not merely in his relation to time, but in his relation to eternity. Our view must not be confined to his temporary condition on earth, but it must extend to his eternal destinies beyond death and the grave. Hence it is that all attempts to separate secular from religi-

ous knowledge are vain and futile. Secular knowledge, as regards itself, is fleeting and evanescent, and will be swallowed up by one glimpse of the glorics of eternity. It may and does exalt the pride of human intellect; it renders poor man proud of his attainments; it makes him think himself something, when, in reality, he is nothing (Gal. vi. 3); "it is a knowledge which puffeth up" (2 Cor. viii. 1), an airy nothing which does not edify or build up on a solid foundation. It may tell us of a great First Cause, of a God of power and might, but it reveals to us nothing of His character as a God of holiness and purity, and at the same time a God of salvation. It spoils man, as St Paul says, "through philosophy and vain deceit, after the traditions of men, after the rudiments of the world, and not after Christ, in whom dwelleth all the fulness of the Godhead bodily."—(Col. ii. 8, 9.) Human intellect becomes an idol, and is worshipped independently of Him who lighteth every one that cometh into the world. Ryle, in one of his excellent tracts, says, "It is not atheism I fear so much in the present time as pantheism. It is not the system which says nothing is true, so much as the system which says every thing is true.

It is not the system which says there is no Saviour, so much as the system which says there are many saviours, and many ways to peace."

3. Do we then despise secular knowledge? Certainly not. We know that, when properly acquired, it is of the greatest importance. But we desire that it should be sanctified by God's Spirit,—that the contemplation of the various works of God in creation and providence should be made subservient to the advancement of the kingdom of grace, —that they should be studied in the light of God's Word, and thus be made to promote His glory and our everlasting happiness.

"The desire which tends to know
The works of God, thereby to glorify
The great Workmaster, leads to no excess
That reaches blame, but rather merits praise,
The more it seems excess;
For wonderful, indeed, are all His works,
Pleasant to know, and worthiest to be all
Had in remembrance alway with delight."

"The fear of the Lord is the beginning of knowledge" (Prov. i. 7), and it is only the fool who despises "the wisdom from above, which is first pure, then peaceable, gentle, and easy to be entreated, full of mercy and good fruits, without partiality and without hypocrisy."—(James iii. 17.)

4. The wise man tells us to get understanding (Prov. iv. 7); and where is that understanding to be got? Only in the Word of truth, which is the foundation of all knowledge, being "able to make us wise unto salvation." Then, indeed, we shall see the littleness of all earthly learning when compared with heavenly wisdom; and while we contemplate the height and the depth of the knowledge still to be acquired, we shall perceive the comparative insignificance of all mere human efforts, and will be led to cultivate that humbleness of mind which ought ever to charaeterize the true man of science. How delightful is it to contemplate God in all his works, and to know that all proclaim him as a God, not merely of almighty power, but of wondrous love. This happiness can only be enjoyed when we are led by the Spirit to view all in Christ. The language of Revelation is, that Christ made the world (John i. 10; Eph. iii. 9), and that by Him all things subsist. This is not the mode in which human learning speaks to us. "The world by wisdom knew not God."—(1 Cor. i. 21.) What a different aspect does creation wear to a Christian from that which it presents to one who is without God in the world! He per-

ceives in all the hand of a Father who is leading him by green pastures and still waters to his heavenly kingdom. He feels that all things are his in Christ, by the fullest and clearest title. As the Spirit of God at the first brooded on the face of the deep and brought light and beauty on what was dark and void, so by His gracious influence He enables the believer to view all creation with the enlightened eye of faith, and to see in it an order, a beauty, and an adaptation, such as cannot be appreciated by the mere worldling. He uses the world as not abusing it, knowing that the fashion thereof passeth away.—(1 Cor. vii. 31.)

5. Our Saviour often spiritualized natural objects when he conversed with man in his bodily presence. Thus, says Austen, "when the Pharisees spoke of washing their hands before meat, Christ instructs them about spiritual defilement (Matt. xv. 20); when the woman of Samaria came to draw water, He told her of living water (John iv. 10); when His disciples brought to Him meat, He tells them that He had meat to eat which they knew not of,—that it was His meat and drink to do the will of His Father (John iv. 34); when the man spoke of his inheritance divided (Luke xii. 13), Christ instructs him and

others to beware of covetousness and worldly cares; when the multitudes followed Him after having eaten of the loaves, He counsels them to labour for the meat which does not perish, even for the bread of life.—(John vi. 26.)" The works of God supply many illustrations calculated to aid the Christian in his search after truth. Our blessed Lord in His teaching makes use of the objects around Him in the delivery of the gospel message, and employs the phenomena furnished by plants as the humble instruments of exhibiting to the minds of His hearers the precious doctrines of His Word. Thus it is that He sanctified such means of instruction; and we fail to ascertain the true mind of the Spirit in such passages, if we do not fully understand the meaning of the illustration. Cheever remarks, "that it is frequently necessary to resort to existing realities in order to explain texts of Scripture otherwise inexplicable, and which to the infidel vulgar, to men of the kin of Voltaire and Tom Paine, serve only for ignorant and senseless ridicule." We ought ever to remember, that "all Scripture is given by inspiration of God, and is profitable for doctrine, for reproof, for correction, for instruction in righteousness."—(2 Tim. iii. 16.) There is no part of

it unimportant. It is a rich mine which cannot be too deeply worked. All our knowledge may be made to bear upon it in such a way as to bring out more of the pure gold. The weeds which strew our path, and the trees and flowers which adorn our gardens and fields, may, in the hands of an enlightened Christian, lead to a clearer view of many statements contained in God's Word.

6. In the Bible, there is continual reference to the imagery supplied by the material world. The words of Scripture appeal not only to the understanding, but also to the sentiments and affections. They call attention to the beauty of the world around, and they make all subservient to the great end of promoting the glory of God and man's eternal interests. It is said, that "besides the various references made, in the pages of Holy Writ, to natural objects in general, there are more than 300 places in which plants are mentioned. Sometimes they occur in Scripture narratives, and tell us of ancient usages; often they remind us of the character, soil, and climate of the scenes of some of the most solemn events of history; in some cases they serve to identify the spots on which they once flourished, as those on which they flourish

still; but more often they are emblematic, and are types of persons or of events, or serve as figures by which the feelings of the reader shall be raised from things seen to those which are unseen. But they were never intended to be regarded merely as ornaments of poetry. They had all their lessons, from the Lily of the Valley and the Rose of Sharon, which foreshadowed a coming Lord, down to the Thorn and Thistle, which tell us even yet of man's sin and sorrow."

7. God's object in creation is the manifestation of Himself; and the contemplation of His works, while it calls forth our wonder and admiration, should lead us to higher views of the Divine economy in bringing before us that new earth wherein righteousness is to dwell. "It is in the soil of this small planet that He is sowing His seed, and raising, as in a nursery, those plants which are yet to clothe a glad universe with their everlasting verdure. It is out of the mountains of this planet that He is hewing the stones with which He is yet to build for Himself a temple in every star of the firmament. It is here that He is constructing the materials, and sketching the design, for His palace. It is here that He is weaving and adorn-

ing His robes of royal state with the materials furnished by this orb. It is of the gold of this earth that He is fashioning a sceptre for the hand, and a crown for the head, of Him who is to be Sovereign of the universe. It is from among the lowly dwellers of this narrow region that He is choosing for that King a Bride to share His glory and His love; nay, it is out of this very earth that this King himself is to arise, or rather, we should say, has arisen; for He who is to have dominion here as King of kings and Lord of lords, is an inhabitant of this planet, the native of a Judean village,—Jesus of Nazareth, the woman's seed!"

It is hoped that, by the blessing of God, this little treatise may be the means of leading some to a more diligent study of the Scripture illustrations, and of exhibiting the science of Botany in its proper light.

CHAPTER I.

ON THE GENERAL DISTRIBUTION OF PLANTS OVER THE GLOBE.

8. Under the name of natural science are included a description of the objects presented to us in the material world, a systematic arrangement and classification of them, a consideration of the various forms which they assume, of the functions which they perform, of the changes which they undergo, and of the mutual relations which they bear to each other. Studied by some for amusement or the love of knowledge, and by others for professional purposes, it has become an important part of education, and no arguments are required to prove the advantages to be derived from it. By directing the attention to various external objects, it acts most beneficially on the observant faculties, and calls the perceptive powers into vigorous action. It teaches the student to mark the differences and resemblances of objects, and promotes the formation of orderly and systematic habits. It benefits

the mind too, by investing familiar objects with new and increasing interest; and thus the naturalist finds active, healthy, and cheerful occupation for every moment.

9. "Whoever," says Roscoe, "has turned his mind so as to comprehend the extensive system of the vegetable kingdom, in the manner as at present taught, and has traced this system through its various connections and relations, either descending from generals to particulars, or ascending by a gradual progress from individuals to classes, till it embraces the whole vegetable world, will, by the mere exercise of the faculties employed for this purpose, acquire a habit of arrangement, a perception of order and distinction, and subordination, which it is not perhaps in the nature of any other study so effectually to bestow. In this view, the examination of the vegetable kingdom seems peculiarly proper for youth, to whose unperverted minds the study of natural objects is always an interesting occupation, and who will not only find in this employment an innocent and a healthful amusement, but will familiarize themselves to that regulated train of ideas, that perception of relation between parts and the whole, which is of use, not only in the pursuit of this delightful study, but in all the concerns of life. Besides the acquisition of order and arrangement, the bodily senses are highly improved by that accuracy and observation

which are necessary to discriminate the various objects that pass in review before them."

10. The true student of natural history does not confine his attention to mere isolated portions of creation; he studies the harmony of all parts of it, and thus acquires comprehensive views of the unity of the works of God, and of the beautiful adjustments which exist in creation as a whole.

> "Happy is he who lives to understand
> Not human nature only, but explores
> All natures,—to the end, that he may find
> The law that governs each; . . .
> . . . that does assign
> To every class its station and its office
> Thro' all the mighty commonwealth of things,
> Up from the creeping plant to sovereign man."

11. The objects with which we are surrounded in the material world, range themselves under two very distinct heads—the *inanimate* or *unorganized*, and the *animate* or *organized*. The study of the former, or of inert matter, is peculiarly the province of Chemistry and Mineralogy, while the consideration of the latter, or of living bodies, belongs to the *Biological* sciences, as they are termed, of Botany and Zoology. Geology, in place of being denominated a separate science, may be considered as the means by which the sciences of Zoology, Botany, and Mineralogy are grouped together in one harmonious system.

12. Every one must have recognised in the world around him many evident distinctions be-

tween living beings and inanimate objects. Perhaps the most apparent and positive of these distinctions, Dr Carpenter remarks, "is based rather upon a comparison of their mode of existence, than upon an examination of their intimate structure. The ceaseless tendency to *change* manifested in the life of the former, stands in obvious contrast with the unaltering stability of the latter. The snow-capped mountain rears its summit to the clouds comparatively unaffected by the lapse of ages which have rolled by since its first elevation. But what, compared with *its* permanence, is the duration of any structure subject to the conditions of vitality? To be born—to arrive at maturity—to die and to decay, is the sum of the history of every being that lives, from man in the pomp of royalty and the pride of philosophy, to the gay and the thoughtless insect that glitters for a few hours in the sunbeam, and is seen no more; from the stately oak, the monarch of the forest through successive centuries, to the humble fungus which shoots forth and withers in a day. How simply, yet how expressively, are these changes described in the words of the sacred writer: 'Our life is as a vapour, which appeareth for a little time and then vanisheth away.'" *

13. Unorganized bodies consist of separate particles, or molecules, united together in definite pro-

* See Preface to Carpenter's Principles of Comparative Physiology.

portions by the force of affinity, and governed by physical and chemical laws. They are either arranged in shapeless homogeneous masses, forming what are called simple minerals, or they assume certain definite and regular geometric figures, and present themselves to us in the form of crystals. Any increase made to these bodies takes place by additions externally. In a solid state they constitute the crust of the earth, when liquid they form the ocean, and when gaseous, the atmosphere of our globe.

14. Organized bodies, on the other hand, while they likewise are composed of elementary atoms, are distinguished from inorganic matter, by not being homogeneous in structure, and by the mode of their increase, which takes place by the assimilation of certain particles received into cavities, and elaborated by a peculiar process into specific compounds, adapted for the nutriment and development of the individual.

15. Botany has reference to the latter class of bodies, and embraces that division of *organized* nature to which the comprehensive appellation of the vegetable kingdom has been given. The merits of this science have too often been depreciated, by those who ignorantly look upon it as consisting only in the application of learned names to the vegetable productions of the globe. The naming of plants is merely means to an end; and is far from being the

true aim of botany. No one can assume an elevated position in botanical science, who is not conversant with the structure and physiology of plants, as well as with their external forms and aspects. The time when the acquirements of a naturalist were measured by the number of species he had collected, is now gone by; and names and classifications are looked upon by the man of enlightened views as but the mechanism by which the true principles of science are to be worked out.

16. Botany, then, aspires to something higher, and more worthy of attention, than the mere naming of plants. Regarding them as organized beings, and as occupying an important place in the scale of creation, it examines the anatomical structure of their various organs, the functions which they perform, the relations which they bear to other objects whether animate or inanimate, the purposes to which they are subservient in the economy of nature, and the uses to which they are applied. In accomplishing these ends, it takes an enlarged and comprehensive view of the vegetation with which the earth is clothed, and embraces a consideration of the varied aspects under which plants appear in the different quarters of the world.

17. To see the extent of the science, let us very briefly contrast a few of the vegetable forms with which the earth is clothed. As regards land-plants, we have at one extremity of the scale the

lichens, such as the small Lecidea which forms the green spots on alpine summits, or the *Tripe* of the arctic rocks (*Gyrophora*), on which Franklin and his daring companions subsisted for many weeks, or the Parmelia of cold regions, as represented in fig. 1, with its rounded spots of fructification,

Fig. 1.

containing minute germs, which are blown about by the winds like thin smoke, and which require the aid of the microscope to see them distinctly. At the other extremity, we have the majestic Palms of the tropics, as represented by the Coco-nut in fig. 2 *a*, with its lofty unbranched stem, upwards of 100 feet high, having a crown of leaves at its summit, and a large cluster of fruit, which supplies an important article of food to the inhabitants of warm regions. In the case of aquatic plants, we pass from the minute duckweed (*Lemna minor*), the green mantle of our pools (fig. 3), with its leaves less than a quarter of an inch in diameter, its flowers scarcely visible, and its delicate roots hanging in the water, with their beautiful sheathed

Fig. 1.—Lichen (*Parmelia*) with rounded spots of fructification, containing minute germs.

Fig. 3.

a Fig. 2. *b*

points, to the enormous Victoria regia of the

Fig. 2, *a*.—Coco-nut Palm (*Cocos nucifera*), with its unbranched stem, crown of leaves, and cluster of fruit. Grows well near the sea, and furnishes food and clothing to the inhabitants of coral islands.

Fig. 2, *b*.—Screw Pine (*Pandanus odoratissimus*), with branched stem, cluster of narrow leaves arranged like a corkscrew, and numerous props in the form of aerial roots which support the stem. Found on coral islands and in warm regions.

Fig. 3.—Duckweed (*Lemna minor*), a minute plant forming a green covering of pools. The minute flowers arise from the floating leaves, and the roots are entirely in the water, their extremities being provided with a little sheath, which is a beautiful microscopic object.

South American waters (fig. 4), having its leaves

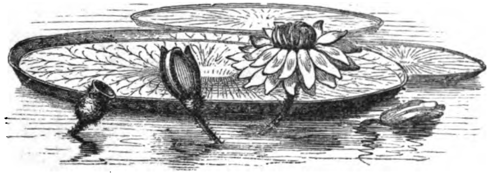


Fig. 4.

six feet in diameter and its showy flowers one foot

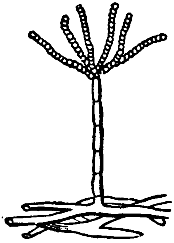


Fig. 5.

across. If we take parasites, or plants living upon others, we have a remarkable contrast between the minute mould (*Penicillium*), (fig. 5), with its cellular spawn or root-like processes, its slender stalk and its microscopic bead-like germs, and the gigantic

Fig. 4.—*Victoria regia*, the largest known water-lily, found in lagoons in South America. Its leaves 4–6½ feet in diameter, and flowers 1 foot across. The plant has recently flowered in warm tanks in several hothouses in Britain, as at Chatsworth, Sion House, Kew, Veitch's Nursery, Exeter. An interesting account of this plant, and of our native water-lilies, has been published by Mr George Lawson.

Fig. 5.—A minute parasitic fungus constituting a kind of mould (*Penicillium.*) There are root-like processes below which form the spawn or matrix whence the plant arises. By means of these it feeds on vegetable substances. Its stalk is composed of cells or little bladders placed end to end, and at the summit are numerous bead-like bands containing minute microscopic germs. The spawn of this mould, branching and interlacing in a peculiar way, so as to form a rounded leathery-like mass, is said to be the plant which has recently been noticed as giving rise to the acetous fermentation, and producing vinegar when put into syrup. In this condition, it separates in a remarkable manner into two portions after a period of six weeks or two months, each forming an independent mass capable of going through the same process of division.

Rafflesia of Java (fig. 6), composed of a conspicuous

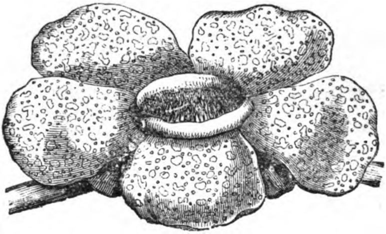


Fig. 6.

brown-coloured flower, three feet in diameter, and capable of holding twelve pints of fluid in its cup.

18. Widely separated though these plants may be in their physical characters, they are all mutually subservient to each other. Every member of the vegetable kingdom, from the most lofty to the most minute and transient—from the cedar on Lebanon, to the hyssop on the wall, has its peculiar office, and is fitted to effect an especial end in the economy of nature.

> "Each moss, each shell, each insect, holds a place,
> Important in the plan of Him who formed
> The scale of beings;—holds a place, which, lost,
> Would break the chain, and leave a gap,
> That nature's self would rue." . . . .

19. Lichens and mosses,—plants so minute as to be overlooked by the ordinary observer,—are

Fig. 6.—*Rafflesia Arnoldi*, a gigantic parasite found in Java and Sumatra. The plant consists entirely of a flower, with roots by which it attaches itself to other plants. The flower is of a peculiar brown colour, and is three feet in diameter.

the means employed by the Creator to prepare a soil in which the seeds of the higher plants can vegetate. Sometimes, as Humboldt remarks, in his "Aspects of Nature," volcanic forces suddenly elevate above the surface of the boiling waves a rock covered with scoriæ; sometimes by a long-continued and more tranquil series of phenomena, the collective labours of united zoophytes raise their cellular dwellings on the crests of submarine mountains, until, after thousands of years, the structure reaches the level of the ocean, when the creatures which have formed it die, leaving a low, flat coral island. No sooner is the rock of the newly-raised island in direct contact with the atmosphere, than there is formed on its surface a soft, silky net-work of lichens, appearing to the naked eye as coloured spots and patches.

20. The lava poured forth by a volcano is no sooner cooled than it is occupied by patches of lichens, (fig. 1, page 17.) The reproductive, although invisible, germs of these plants are produced in vast abundance, and are constantly floating in the atmosphere, ready to alight on any object that may come in their way. Many of them have the power of adhering to rocks, and of causing their disintegration. From the materials of the rocks, aided by the atmosphere and moisture, they are able to derive all the requisites for their growth and nourishment. In this way they prepare a slight

stratum of vegetable mould, and by their decay form a soil in which mosses and ferns can grow. These in their turn decaying, make way for grasses and rock-plants, and by successive changes a soil is produced in which the seeds of trees can vegetate, when carried thither by the agency of winds or other causes.

21. To such minute agents do we trace the soil formed on the coral islands of the Pacific Ocean, which ultimately affords nourishment to the Coco-nut Palm, (fig. 2, *a*. page 18.) This palm, all parts of which are put to some use, grows luxuriantly on coral-made islands after their emergence from the ocean. It furnishes to the natives food, drink, clothing, materials for building, utensils of all kinds, mats, cordage, fishing-lines, and oil. The Pandanus or Screw Pine, (fig. 2, *b*,) is another early inhabitant of coral islands, where it flourishes luxuriantly. As its branches spread, it sends out prop after prop to support the trunk, and to fix the tree in the ground. Its large mass of fruit affords a sweetish article of food, which can be kept for some time. By means of these fruits and by fishing, a population of 10,000 persons are supported, according to Dana, on the single island of Taputeouea, whose whole habitable area does not exceed six square miles.

22. In nothing is God's infinity and man's littleness more strikingly exhibited and contrasted, than in the operations of nature upon a grand scale; and

this is particularly evident in the instance of the formation of the coral islands, and their vegetable productions. The extreme simplicity of the means employed for the attainment of such vast ends, cannot but be a subject of astonishment and admiration to every reflecting mind; and this simplicity is apparent in all the ways and workings of God. In fig. 7, is represented one of these

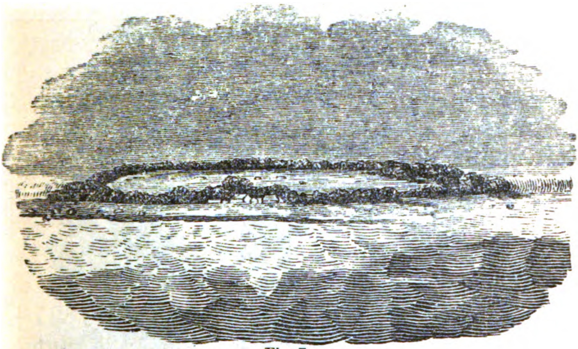


Fig. 7.

coral islands in the Pacific Ocean, the centre occupied by a lake, and the circumference formed by a madreporic reef, on which vegetation flourishes. The means by which such islands are constructed are seen in figs. 8, 9, 10, which represent some of the polyps that unite in this work. Each of the specimens consists of an immense number of these

Fig. 7.—A madreporic or coral island in the Pacific Ocean, with a lake in the centre.

minute animals united together on a common stalk

Fig. 8.

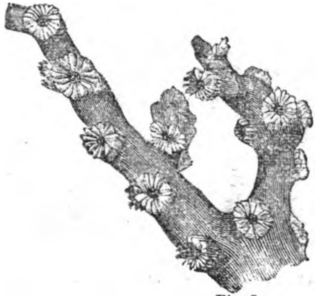


Fig. 9.

Fig. 10.

or base, forming their durable polypodoms or polyp-houses, and thus gradually accumulating large masses of hard materials which resist the action of the waves, and ultimately form solid land. How

Fig. 8.—Meandrina labyrinthica, a species of coral polyp. The whole mass consists of numerous polyps combined.

Fig. 9.—Oculina hirtella, another set of coral polyps.

Fig. 10.—Madrepora muricata, a third set of coral polyps.

beautifully are the labours of these animals referred to by James Montgomery in the following lines:—

> "Unconscious, not unworthy, instruments,
> By which a Hand invisible was rearing
> A new creation in the secret deep.
> Omnipotence wrought in them, with them, by them;
> Hence what Omnipotence alone could do,
> Worms did. . . . . .
> . . . . . .
> Atom by atom thus the burthen grew,
> Even like an infant in the womb, till time
> Delivered ocean of that monstrous birth,
> —A coral island, stretching east and west,
> In God's own language, to its Parent saying,
> 'Thus far, no farther, shalt thou go; and here
> Shall thy proud waves be stayed':—a point at first,
> It peer'd above those waves; a point so small,
> I just perceived it, fix'd where all was floating;
> And when a bubble cross'd it, the blue film
> Expanded like a sky above the speck;
> That speck became a hand-breadth; day and night
> It spread, accumulated, and ere long
> Presented to my view a dazzling plain,
> White as the Moon amid the sapphire sea."

23. When compared with this amazing edifice, raised by the weakest creatures in existence, what are all the works of man? How different is it with his designs! How complicated are the means which he employs for the attainment of his projects! D'Aubigné well remarks:—"When man would raise a shelter against the weather,—a shade from the heat of the sun,—what preparation of materials, what scaffolding and crowds of workmen, what trenches and heaps of rubbish! But when God would do the same, he takes the smallest seed,

that a new-born child might clasp in its feeble hand, deposits it in the bosom of the earth; and from that grain, scarcely distinguishable in its commencement, he produces the stately tree, under whose spreading branches the families of man may find a refuge."

24. The small germ of life deposited in the earth, is acted on by moisture, heat, and air; and thus accomplishes all the wonders of creation. The fluid enters the rootlets, the sap rises through the tubes and cavities by a beautiful law of imbibition and attraction, it reaches the branches and the upper part of the leaves, is exposed to the action of air and light, and then returns by the lower surface of the leaves to the bark, forming in its course various secretions and products which are required for the purposes of vegetable life. A few simple elements in the hand of the Creator are all that are required to work out this great plan.

"Thus He who makes and peoples worlds still works
In secrecy, behind a veil of light;
Yet, through that hiding of his power, such glimpses
Of glory break, as strike presumption blind,
But humble and exalt the humbled soul,
Whose faith the things invisible discerns,
And God informing, guiding, ruling all,—
He speaks, 'tis done; commands, and it stands fast;
He calls an island from the deep—it comes;
Ordains it culture—soil and seed are there."

25. The lichens and mosses of the arctic and antarctic regions are slowly preparing a soil for a more highly-organized race. The summit of the

mist-crowned mountain, although unproductive of any of those plants which are directly useful to man or animals, is covered with lichens, preparing a soil which is afterwards carried down by the streams to fertilize the plains below. The most despised weeds thus lay the foundation for the growth of the trees of the forest; and in the course of a few years, the sterile rock or coral-formed island is converted into a natural and luxuriant garden. By Nature's chemistry, the bare rock becomes buried in crumbling mould, in which from time to time the seeds of plants are deposited. By degrees, the slender blades of grass shoot through the dark brown earth, the green herbage covers the soil, flowers expand their blossoms, and shrubs and trees adorn the landscape,—

> "Seeds, to our eye invisible, can find
> On the rude rock the bed that fits their kind;
> There in the rugged soil they safely dwell,
> Till showers and snows the subtle atoms swell,
> And spread th' enduring foliage; then we trace
> The freckled flower upon the flinty base:
> These all increase, till, in unnoticed years,
> The sterile rock as grey with age appears
> With coats of vegetation thinly spread,
> Coat above coat, the living on the dead;
> These then dissolve to dust, and make a way
> For bolder foliage nursed by their decay."

26. As with God's works of creation and providence, so it is with his work of grace. By imperceptible means he accomplishes his mighty plans. The dawning of light in the mind of man is often

unseen at first, but it gradually brightens into the perfect day. The little leaven leavens the whole lump. The small mustard seed becomes the tree.* The spark of grace is fanned into flame, and pervades the entire inner man. From the contemplation, then, of all God's works, let us learn not to despise the day of small things. God often chooses those who are despised by the world to work out His mighty plans. "The weakness of God is stronger than men." "Not many wise men after the flesh, not many mighty, not many noble, are called: but God hath chosen the foolish things of the world to confound the wise; and God hath chosen the weak things of the world to confound the things which are mighty; and base things of the world, and things which are despised, hath God chosen; yea, and things which are not, to bring to nought things that are: that no flesh should glory in his presence."—(1 Cor. i. 25–29.) The despised fishermen of Galilee were chosen as his missionaries to proclaim the truth, to advance his kingdom, and to prepare the way for the new earth, wherein righteousness shall dwell. Truly "His ways are not as our ways, nor His thoughts as our thoughts."—(Isa. lv. 8, 9.) "How unsearchable are his judgments, and his ways past finding out."—(Rom. xi. 33.)

* It may be noticed here that the mustard-plant of Palestine is not a herbaceous plant like that of Britain, but is in reality a tree (*Salvadora persica*) on the branches of which the fowls of the air can lodge.

27. Wherever circumstances are compatible with vegetable existence, there we find plants arise. The solitary island in the midst of the ocean, as well as the extended continent; the parched desert, and the fertile plain; the deep cavern, and the lofty mountain; the stagnant pool, and the meandering stream, have each their peculiar vegetation. Even the sides of the volcano are covered with flowers; and the geysers of Iceland, and the hot-springs of Switzerland and Arabia, are not without their vegetable productions. The ever-sounding and mysterious deep hides in its bosom many a plant no less conspicuous for beauty and variety of form than splendour of colour, and admirably fitted for the place it is designed to occupy. On the sands of the torrid zone, the eye of the traveller is occasionally refreshed by the appearance of a few succulent plants which are enabled to thrive amidst these arid regions; and in the realms of perpetual snow which surround the poles, attention is arrested by the prospect of fields of red snow, which owe their existence in part to plants of a microscopic nature. Thus it is that vegetation is spread over all quarters of the globe, and is wisely adapted to all varieties of climate.

28. "The carpet of flowers and of verdure," Humboldt remarks, "spread over the naked crust of our planet, is unequally woven: it is thicker where the sun rises high in the ever-cloudless heavens, and

thinner towards the poles—in the less happy climes where returning frosts often destroy the opening buds of spring, or the ripening fruits of autumn. Every where, however, man finds some plants to minister to his support and enjoyment." Those who view nature with a comprehensive glance, Humboldt continues, "see, from the poles to the equator, organic life and vigour gradually augment with the augmentation of vivifying heat. But in the course of this progressive increase, there are reserved to each zone its own peculiar beauties; to the tropics, variety and grandeur of vegetable forms; to the north, the aspect of its meadows and green pastures, and the periodic awakening of nature at the first breath of the mild air of spring. Each zone, besides its own peculiar advantages, has its own distinctive character—each region of the earth has a natural physiognomy peculiar to itself. The idea indicated by the painter, by expressions such as *Swiss nature, Italian sky*, &c., rests on a partial perception of this local character in the aspect of nature. The azure of the sky, the lights and shadows, the haze resting in the distance, the form of animals, the succulency of the plants and herbage, the brightness of the foliage, the outline of the mountains, are all elements which determine the total impression characteristic of each district or region."

29. While the Creator has bountifully distributed

His floral gifts in every quarter of the globe, it is in warm climates that vegetation displays its most majestic forms. There we meet with the Baobab, one of the oldest living monuments of the globe, with its trunk 30 feet in diameter, and its foliage forming a mass of enormous dimensions. (Fig. 11.)

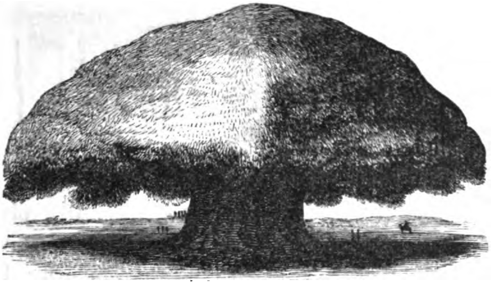


Fig. 11.

There we find the branching Banyan, with its numerous stems (fig. 12), forming a "pillared shade high overarched, with echoing walks between," and thus described by Southey:—

"'Twas a fair scene wherein they stood,
A green and sunny glade amid the wood,
And in the midst an aged Banyan grew.
It was a goodly sight to see
That venerable tree;
For o'er the lawn, irregularly spread,
Fifty straight columns propt its lofty head;
And many a long depending shoot,
Seeking to strike its root,
Straight like a plummet grew towards the ground."

Fig. 11.—Baobab tree of Senegal (*Adansonia digitata*), one of the largest known trees, its stem having a diameter of 30 feet.

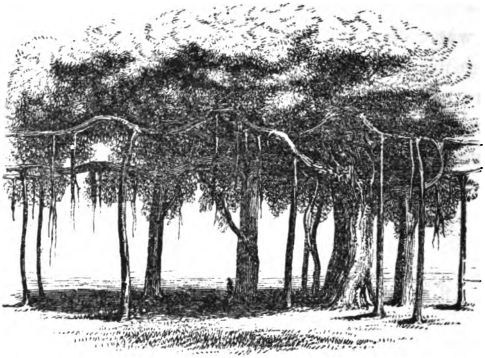


Fig. 12.

There grow the palms (fig. 2 *a.* page 18), plantains, and bananas (fig. 13), with their large leaves and abundant fruit. There the air-plants (fig. 14) enliven the trunks of the gigantic trees, and climbing-plants develop their gorgeous blossoms. There the richest fruits and spices are produced, flowers of the most varied hues unfold themselves, and the air is perfumed with the most fragrant and balmy odours. There the Cymbidium and fragrant Vanilla enliven the trunks of the Anacardiums and the gigantic fig-trees. The fresh verdure of the Pothos leaves and of the Dracontias, contrasts with the many-coloured flowers of the Orchis (fig. 14); climbing Bauhinias, passion-flowers, and yellow-flowering

Fig. 12.—Banyan tree of India (*Ficus indica*), with numerous aerial roots descending from the branches and forming separate stems.

Banisterias, twine round the trunks of the forest

Fig. 13.

Fig. 14.

trees. Delicate blossoms spring from the roots of the chocolate-tree (fig. 15), and from the thick and rough bark of the calabash and Gustavia. In the midst of the profusion of flowers and fruits, and in the luxuriant intertwinings of the climbing plants, the naturalist often finds it difficult to discover to

Fig. 13.—Banana (*Musa sapientum*), a plant of warm countries, having an underground stem, which sends up a temporary herbaceous stem, formed by sheathing leaves, as seen in the figure. The fruit is produced in clusters at the summit. The flowers near the end of the flower-stalk are abortive ; those at the base of the stalk produce fruit.

Fig. 14.—An air-plant or orchid (*Dendrobium*), with succulent bulbous-like stems, growing attached to trees in warm climates.

C


Fig. 15.

what stem the different leaves and flowers really belong.

30. In tropical regions, the luxuriance of the vegetation is not more remarkable than the rapidity of its growth. After the dry season in the Brazilian plains, and when the first few showers have fallen, the annual grasses shoot forth their blades, the trees burst into leaf and blossom, and the perennial herbaceous plants, which during the drought were apparently destroyed, throw up their flowering stems with astonishing vigour. In the neighbourhood of the Cape of Good Hope, after the cessation of the rainy season, the earth becomes parched, vegetation languishes, and the leaves wither and die, so that all appearance of verdure and life is lost, till on the first fall of rain it suddenly revives, and the plains become immediately covered with a countless variety of blossoms and flowers.

31. As we proceed from warm regions towards the poles, we find that as the light and heat diminish, vegetation is checked in the same proportion. At every step of our progress we change the vegetable group. From the hottest climates we pass in

Fig. 15.—Chocolate Tree (*Theobroma Cacao*). It yields Cacao beans, from which chocolate is prepared.

succession through those of the pine-apple, sugar-cane (fig. 16), coffee (fig. 17), date (fig. 18), cotton,


Fig. 16.


Fig. 17.


Fig. 18.

citron, and olive, till we reach the region of the vine. The spices and fruits of equatorial Asia are succeeded, in the thickets to the east of the Caspian, by the apricot, the peach, and the walnut. In the southern regions of Europe, the dwarf palm, the cypress, and the cork tree (fig. 19), make their appearance; the orange and lemon perfume the air with their blossoms, and the myrtle and pomegranate grow wild among the rocks. Again, when we

Fig. 16.—Sugar-Cane (*Saccharum officinarum*).

Fig. 17.—Coffee Tree (*Coffea bengalensis*), with its succulent berries, containing coffee seeds.

Fig. 18.—Date Palm (*Phœnix dactylifera.*) The Palm mentioned in the Bible. It yields the fruit called dates, which hang in clusters from the top of the stem, as seen in the figure.

pass the Alps, we find the vegetation of northern climates; forests of oak, beech, and elm adorn the landscape, and are ultimately replaced by various species of hazel, fir (fig. 20), and birch.

Fig. 19.

32. The vegetation of cold regions does not assume any of the grandeur and luxuriance which we observe in the tropics. As we approach the shores of the Arctic Ocean, the trees become few and diminutive. In Siberia, their thin and distorted trunks are clad, as it were, with a fur-like covering of lichens, which occupy the place of the orchids of warm regions. Further north, the only shrub we find is the dwarf birch; and beyond the

Fig. 20.

Fig. 19.—Cork Tree (*Quercus Suber*) found in the south of Europe. Its outer bark furnishes the cellular substance called cork.

Fig. 20.—Scotch Fir (*Pinus sylvestris*), a tree of cold climates.

70th degree not a tree or shrub is to be seen. Spitzbergen is said to produce only one plant possessed of a proper woody stem; mosses form more than a quarter of the whole vegetation of Melville Island, and the soil of New South Shetland is covered with specks of mosses struggling for existence. Dr Hooker states that on one of the antarctic islands he gathered the *ghosts* of eighteen cryptogamic plants, chiefly mosses and lichens; and that there appeared no trace whatever of flowering plants. Even in those regions where snow lies upon the ground during the greater part of the year, the Creator calls into existence peculiar tribes of plants, which are enabled, during the short summer of such inhospitable climes, to pass through their various periods of sprouting, flowering, and fruiting. The plants, so to speak, seem to fear lest they should not be able to perfect their seeds before the cold and darkness arrest their growth.

33. The adaptation of plants to different climates is a subject well fitted to call forth our admiration. The succulent plant (fig. 21), well provided with stores of fluid, and in which evaporation takes place with the greatest difficulty, is made to grow in the parched and thirsty desert. In the deserts of the East, and the sandy plains of Arabia, where the heat from the earth dissipates the passing cloud, which hastens, as it were, to shed its refreshing moisture on a more grateful spot, where no

water issues from a spring or falls from on high, there the water melon grows, offering a delicious draught to the traveller. On the plains of the Pampas, the Cactus (fig. 22), with its juicy stems, like a vegetable fountain, refreshes the wild herds which roam over the plains, and which instinctively tear off the formidable external prickles of the plant in order that they may reach the succulent interior. The Palm developes its umbrageous foliage in those regions where it is most required for shelter from the heat of the sun. The Bread-fruit (fig. 23), Banana (fig. 13, page 33), Plantain,

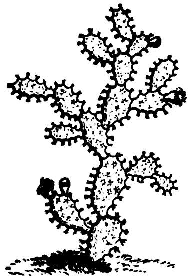


Fig. 21.

Fig. 22.

Fig. 23.

Fig. 21.—Cactus, a succulent plant of warm climates. On a plant of this kind (*Opuntia cochinillifera*) the cochineal insect feeds. The female insects are collected and dried to furnish the dye as imported.

Fig. 22.—Melon Cactus of warm climates, with a peculiar succulent melon-like stem whence the flowers arise. The prickles on the outside are torn off by the cattle in order to get the fluid inside.

Fig. 23.—Bread-fruit tree (*Artocarpus incisa*), with a cluster of stami-

Mango, and Coco-nut (fig. 2, *a*, page 18), are produced in abundance in those climates where they are best fitted for the support and wellbeing of the inhabitants. In temperate climes, where animal food is more essential to existence, we meet with the grassy herbage and the green pastures adapted for the food of cattle; while in arctic regions, the lichen on which the reindeer feeds (fig. 24), thrives at a temperature sufficient to kill most other plants.


Fig. 24.

34. A lofty mountain at the equator exhibits, as it were, an epitome of what takes place, on a grander scale, over the whole globe. It presents to us different climates, and at the same time different zones or belts of vegetation. In the South American plains we meet with palms (fig. 2 *a*, page 18), and Bananas (fig. 13, page 33), in the greatest luxuriance; as we ascend the Andes, we come to tree-ferns (fig. 25), then to the Peruvian-bark trees (fig. 26); passing through the woody region, we arrive at a shrubby zone, succeeded by grassy meadows, and finally we tread on mosses and lich-

niferous flowers forming a spike, and a large globular fruit composed of numerous flowers united. It supplies nourishing food in the South Sea Islands.

Fig. 24.—Reindeer moss (*Cladonia rangiferina*), the lichen on which the reindeer feeds in cold countries.

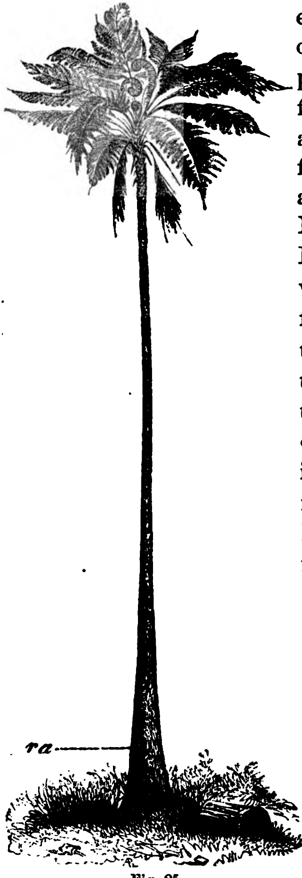


Fig. 25.

Fig 25.—Tree-fern (*Alsophila Perrotetiana*) of the East Indies;

ens, which are limited only by the line of perpetual snow. In fig. 27 a representation is given of the forms of vegetation on a tropical mountain. No. 1 is the region of Palms and Bananas, which is 3000 or 4000 feet above the level of the sea, the temperature ranging from 81° to 71°; No. 2, the region of Tree-ferns, reaching to about 5000 feet, mean temperature 66°; No. 3 indicates the limit of the Vine, in lat. 16° 24′ S., at about 7000 feet; No. 4, the limit of great trees, mean temperature being 61°; No. 5, region of cinchona-bark trees, extending to 9000 or 10,000 feet on the Andes; No. 6, shrubby region, mark-

ed on the Andes by Befarias at about 10,000 feet; No. 7, region of grasses; No. 8, region of lichens and snow line, at about 15,000 or 16,000 feet.

Fig. 26.

35. In order that this general distribution of plants over the surface of the globe may be secured, many of them are provided with a large number of reproductive germs or seeds. In the case of the lower tribes of plants, as mushrooms, puff-balls, &c., the number is almost incredible. In a single plant of this tribe, Fries ascertained the existence of ten millions, so minute as to be scarcely visible, often resembling thin smoke, and so subtile that it is difficult to conceive a place from which they could be excluded. The decay of the higher plants furnishes nourishment for thousands of these mushroom-like tribes (fig. 28), and the trunk of a dead tree will give rise to millions. Bread cannot be kept for many days without becoming covered with blue mould, composed of myriads of minute but perfect plants of this description (fig. 5, p. 19.)

with a tall undivided stem, and a cluster of leaves or fronds at the summit, and towards the base ra presenting a peculiar enlargement owing to a number of aerial roots applied close to the stem. These plants give a peculiar character to the vegetation of some countries, such as New Zealand.

Fig. 26.—Peruvian-Bark tree, a species of Cinchona, found on the Andes at the height of 9000 feet above the level of the sea.

Even in the higher classes of plants, we meet

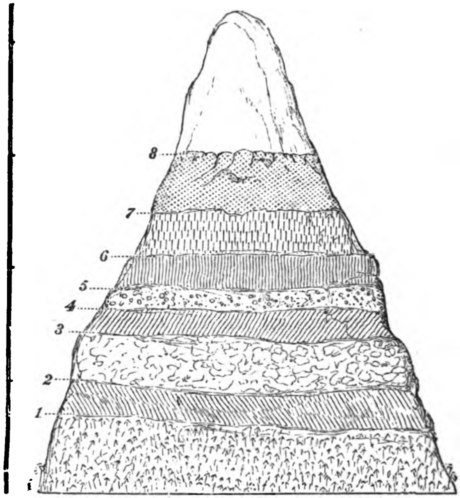


Fig. 27.

with remarkable examples in this respect. The number of seeds produced by a single plant of the Seje palm is about 8000; by the common spear thistle, 24,000; the poppy, 32,000; and tobacco, 40,000, or even more.

36. In order that seeds may be scattered, some

Fig. 27.—Plan of a mountain in the Torrid Zone, with a scale indicating the number of feet, each division of the scale being equal to 1000 feet. 1. Region of palms. 2. Region of tree-ferns. 3. Region of vine. 4. Limit of great trees 5. Region of Cinchona or Peruvian-bark. 6. Shrubby region (Befarias). 7. Region of grasses and some hairy plants, as Culcitium. 8. Region of lichens, ending in snow line.

of them are provided with hairy appendages, as

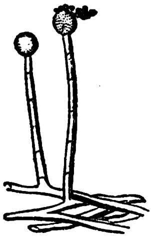


Fig. 28.

cotton, and are thus wafted by the winds to a great distance. Others are dispersed by the agency of water. The mountain stream washes down to the valley the seeds which may accidentally fall into it, or which it may happen to sweep from its banks when it suddenly overflows them. The broad and majestic river, winding along the extensive plain, and traversing the continents of the world, conveys, to the distance of many hundreds of miles, the seeds which may have vegetated at its source. The influence of aqueous agents is also remarkably displayed in causing seed-vessels to open and scatter the seeds in a spot fit for germination. Thus, the plant called Rose of Jericho becomes dried up like a ball, and is tossed about by the wind until it comes into contact with water, when its small pods open, and the seeds are scattered; and a species of fig-marigold in Africa opens its seed-vessel when moisture is applied (fig. 29).

37. Seeds also are enabled, in many cases, to retain their vitality long, so that they can vegetate even

Fig. 28.—A kind of mould (*Mucor*), with a spreading spawn below, a cellular stalk, and a globular head containing numerous minute germs like small dust, easily carried about by the wind. Some of them are seen in the figure in the act of being scattered.

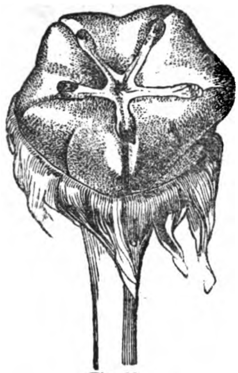


Fig. 29

after being kept for many years, and exposed to various vicissitudes. The coco-nut, supported on the waters of the Pacific by means of the buoyant mass of fibrous covering which surrounds it, is said to have been wafted for 1800 miles on the ocean, with its germinating properties unimpaired.

"With such a liberal hand has Nature flung
Their seeds abroad, blown them about in winds,
Innumerous mix'd them with the nursing mould,
The moistening current, and prolific rain."

It has been justly remarked, "Innumerable are the means which the Great Creator employs in spreading fertility, from the gentle summer wind which ripples the water, to the storm which lashes the waves into fury; from the humble and unintentional ministry of the fowl of the air, to the thoughtful plan, and unwearied pursuit of it, which characterize the works of His great masterpiece, man."

38. While a very superficial glance at the vege-

Fig. 29.—Seed-vessel of a Mesembryanthemum or Fig-Marigold, which, when ripe, spreads open in five pieces, so as to scatter the seeds. When the ripe seed-vessel is moistened, the opening takes place very speedily.

table productions of the globe is thus calculated to call forth our admiration of the wisdom and goodness of God, it is when we examine the minute and microscopic structure of plants, that we are led to still higher views of the wonderful and simple means which He employs to work out His mighty purposes. The more highly we magnify the texture of plants, the more beautiful do they appear. How different are the works of God in this respect from the works of man! The finest lace, as far as regards man's work, when placed under the microscope, becomes coarse; but the vegetable fibre of which the lace is made, when treated in a similar manner, only exhibits more delicacy and beauty.

39. The more we examine the works of God, the more do we see their perfection, the more do we perceive touches of the most masterly skill and wisdom. He is perfect in the greatest, as well as in the smallest; "perfect in appointing the days and hours in which Jupiter, with all his satellites, shall travel round the sun; perfect in framing the smallest insect that creeps over a few feet of our little globe; perfect in the minutest moss which grows on the most solitary island of the ocean." In all man's inventions and performances, there are constantly imperfections and errors to be detected. What he approves to-day, he may ere long reject as his knowledge and his taste improve. In God's works, no fault can be detected in the plan, no

improvement on the first model. They have pleased all tastes, in all ages, and in every country. The simplicity of the means, moreover, by which all His mighty plans are wrought, is a subject of wonder and admiration.

40. In speaking of the wonders of creation, Dr Chalmers remarks :—"About the time of the invention of the telescope, another instrument was formed, which laid open a scene no less wonderful, and rewarded the inquisitive spirit of man. This was the microscope. The one led me to see a system in every star; the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and its countries, is but a grain of sand on the high field of immensity; the other teaches me that every grain of sand may harbour within it the tribes and the families of a busy population. The one told me of the insignificance of the world I tread upon; the other redeems it from all its insignificance; for it tells me that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless are the glories of the firmament. The one has suggested to me, that beyond and above all that is visible to man, there may be fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest scenes of the

universe; the other suggests to me, that within and beneath all that minuteness, which the aided eye of man has been able to explore, there may be a region of invisibles; and that, could we draw aside the mysterious curtain which shrouds it from our senses, we might see a theatre of as many wonders as astronomy has unfolded—a universe within the compass of a point so small, as to elude all the powers of the microscope; but where the wonder-working God finds room for the exercise of all His attributes, where He can raise another mechanism of worlds, and fill and animate them all with the evidence of His glory."

41. As in the minute examination of the works of Providence, so in the enlightened study of God's Word, we shall be led to see more and more of the depth of His unfathomable wisdom. The more it is scrutinized by the microscopic eye of faith, the more beauty, the more wondrous adaptations, are discerned. Truth stands out in bolder relief, and the traces which were previously imperceptible are seen to be lines of mighty import. Thoughts which had passed unnoticed are depicted by this mirror in all their nakedness, and are seen with the most accurate definition in the unerring light of truth, unobscured by the colouring with which we are ready to gloss them over. There must, however, be the eye to see, and the hand to adjust, and these are the gifts of God,

whose Spirit alone can enable us to see light clearly, and to exclaim, The Lord's thoughts are not as our thoughts, nor His ways as our ways. For as the heavens are higher than the earth, so are His ways higher than our ways, and His thoughts than our thoughts.—(Isa. lv. 8, 9.) The wisdom of God in a mystery, even the hidden wisdom, is revealed unto us by His Spirit; for the Spirit searcheth all things, yea, the deep things of God. (1 Cor. ii. 7, 10.)

CHAPTER II.

ON THE STRUCTURE AND DEVELOPMENT OF PLANTS.

42. In prosecuting our botanical illustrations, we shall carry the reader along with us most easily by taking an orderly method,—commencing with a general view of the structure of plants, and then tracing the young plant from its earliest state, through its different stages of growth and development, up to the perfect fruit.

I.—ON THE MICROSCOPIC STRUCTURE OF PLANTS.

43. As regards their minute structure, plants have been divided into those which are composed entirely of small bladders or vesicles called *cells* (fig. 30), united together in various ways

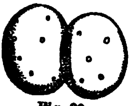


Fig. 30.

Fig. 30.—Two cells or vesicles (magnified), which enter into the composition of plants. The dots are places where the membrane, forming the walls of the cells, is thin.

(fig. 31); and those which are furnished not only with cells, but with long closed tubes called *vessels* (fig. 32). The former are denominated *cellular plants*, and they may be illustrated by mushrooms, moulds (fig. 5, p. 19, and fig. 28, p. 43), sea weeds and lichens (fig. 1, p. 17, and fig. 24, p. 39), which have no conspicuous flowers, and are reproduced by small cellular germs; the latter receive the name of *vascular plants*, and are seen in the case of ordinary trees, shrubs, and herbs which have more or less evident flowers, and are reproduced by true seeds.

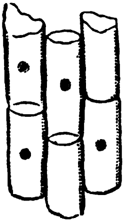


Fig. 31.

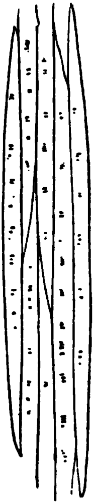


Fig. 32.

44. The structure of the cells and vessels of plants can only be fully seen by the aid of the microscope, an instrument which we shall immediately describe. The examination of these tissues amply repays the trouble attendant upon it. In some cells and vessels there are seen beautiful markings

Fig. 31.—Cylindrical cells (magnified) united together and forming cellular tissue. Some of them are represented as containing small cellules which are employed in the production of new cells.

Fig. 32.—Elongated spindle-shaped woody tubes, closed at each end, and united together, so as to form a kind of vascular tissue (magnified.)

in the form of dots (figs. 33 and 34) or rings (fig.

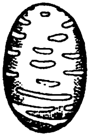


Fig. 33.

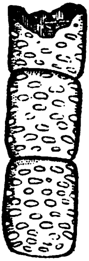


Fig. 34.


Fig. 35.


Fig. 36.

35), or bars (fig. 36), or fibres, coiled up like a cork-screw (figs. 37 and 38.) Hence arise the various names of dotted, annular or ringed, barred or ladder-like, and spiral cells and vessels. These, along with woody tubes (fig. 32), may be seen in different parts of the same plant.

45. Common mould (figs. 5, p. 19, and 28, p. 43) and mushrooms are composed of cells united together; so are the pith of trees, cotton, cork from the outer bark of the cork oak (fig. 19, p. 36), rice-paper, and the paper of the ancients, made from the papyrus—the bulrush of Scripture—whose nodding heads of flowers (fig. 39)

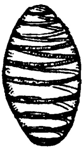


Fig. 37.

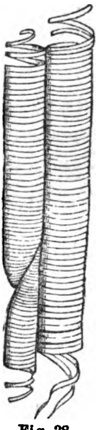


Fig. 38.

Figs. 33 to 38.—Various forms of cells and vessels magnified. 38.

so well correspond with the statement of the prophet, "Bow down his head as a bulrush." All fleshy fruits, as the peach (fig. 40), bread-fruit (fig. 23, p. 38), and succulent roots, as turnip, contain a large quantity of cellular tissue; and the object of the horticulturist in many instances is to increase it, and thus to render vegetables tender and succulent, which would otherwise be tough and dry. Cells often become hardened and thickened by matter deposited inside. Thus the hard shell of seeds, and the stone of

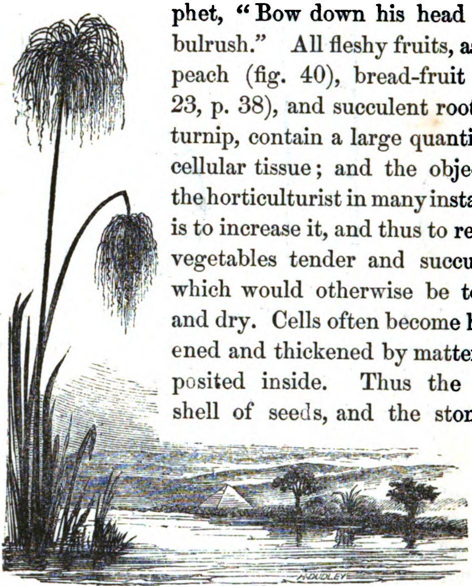


Fig. 39.

fruits, consists of woody cells. The coverings of some seeds, as *Collomia*, exhibit beautiful spiral

Dotted cell. 34. Dotted or pitted vessel composed of united cells with the partitions obliterated. 35. Annular or ringed cell, with fibres in the form of rings. 36. Barred vessel, with lines or bars formed by fibres. 37. Spiral cell, with an elastic spiral fibre inside. 38. Spiral vessels, with spiral fibres inside capable of being unrolled.

Fig. 39.—*Papyrus antiquorum*, the bulrush of Scripture. It grows in the Nile, and is used for making light boats. (Isa. xviii. 2.) The babe Moses was exposed on the Nile in an ark of bulrushes. (Exod. ii. 3.)

cells (fig. 37), the fibres of which, when moistened by water, uncoil in a remarkable manner, and form

a Fig. 40. b

a beautiful object under the microscope. The object of this seems to be to fix the seeds in the moist soil after being scattered. Peculiar annular cells (fig. 35) are met with in Cactuses.

46. The woody parts of plants consist of elongated tubes, tapering to each end (fig. 32, p. 50), and rendered tough by woody matter deposited inside. These woody tubes can be separated from the bark and stems of many plants by maceration or steeping in water; and in this way hemp, flax, and bast are procured. In fig. 41 the plant which furnishes New Zealand flax is shown. Each minute thread of this substance consists of numerous

Fig. 40.—Flowers and fruit of the peach (*Amygdalus persica*). The fruit consists of cellular tissue chiefly; the flesh is composed of succulent cells; the stone of hardened woody cells. *a* Flower-bearing branch, *b* Fruit-bearing branch.

woody tubes overlying each other, as represented in fig. 32, and thus having considerable tenacity. Pitted or dotted vessels (fig. 34) are the largest kind of tubes in plants. They are well seen in the sugar-cane (fig. 16, p. 35), and in the bamboo. Spiral vessels are met

Fig. 41.

with abundantly in the higher tribes of plants. They may be procured from common asparagus after being boiled, by separating the cellular portion in water under the simple microscope. The spiral fibre of the vessels may be exhibited by making a superficial cut round the leaf-stalk of a geranium or strawberry, and then pulling the parts gently asunder. When the coil is unrolled, it appears like the threads of a cobweb. In the common hyacinth and lilies, these spiral fibres can be easily seen. In the case of the banana (fig. 13, p. 33), the spiral fibres are so abundant, that they are pulled out and used as tinder in the West Indies. In the stem of trees, the spiral vessels exist around the pith. In the common garden balsam, many varieties of vessels exist which can be readily separated under the microscope. Peculiar vessels, having bars of fibres arranged like the steps of a ladder, occur in ferns (fig.

Fig. 41.—***Phormium tenax,*** **the plant which yields New Zealand flax, composed of woody vessels (much reduced in size.)**

42), and especially in the stems of tree ferns (fig. 25, p. 40.)

47. Thus all the parts of plants, including root, stem, leaves, flowers, and fruit, are composed of cells and vessels of different kinds, either separate or combined; and by means of these simple tissues the Almighty Creator carries on all the wondrous processes of vegetable life. The absorption or imbibition of nourishing fluids takes place by the cells of the root; the sap then rises through the cells and vessels and intercellular canals of the stem; it reaches the cells and vessels of the leaf, and is there exposed to the action of air and light, so as to fit it for the various secretions given off as it descends through the cells and vessels of the bark. Thus the functions of nutrition or nourishment are accomplished. The cells and vessels of the flower, on the other hand, undergo various changes, so as to enable them to perform the functions of reproduction, or the production of seed.


b Fig. 42. *a*

48. Besides a general movement of sap, there are also special movements occurring in cells and

Fig. 42.—*Athyrium Filix-fœmina*, a British fern. *a* Entire plant much reduced in size, with root and frond bearing fructification; *b* Portion of the frond or leaf magnified to show the fructification.

vessels. In the cells of aquatic plants, such as *Chara* (fig. 43), and *Vallisneria* (fig. 44), there is

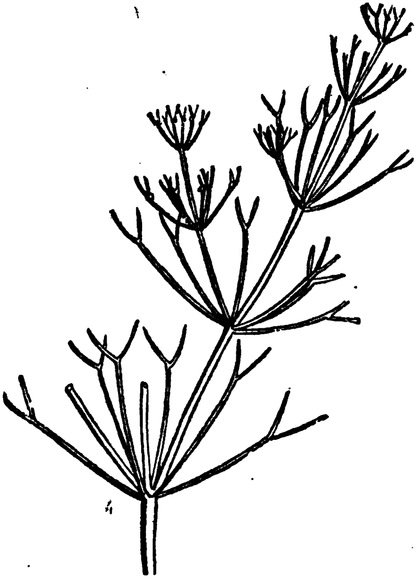
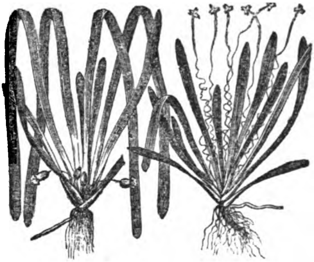


Fig. 43.

a distinct and regular motion of granules, which is easily seen under the microscope. These movements are promoted by moderate heat, and they seem to take place in a spiral manner round the

Fig. 43.—*Chara*, or *Nitella flexilis*, an aquatic plant, composed of elongated cylindrical cells, in which a marked movement of fluids takes place.

cells. They appear to be connected with the life of the individual cell, and the formation of new cells. In the jointed hairs seen in the flowers of the Virginian spider-wort, and in the hairs of the common nettle, similar motions are



a Fig. 44. *b*

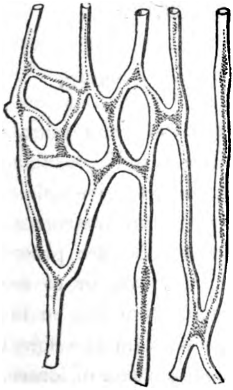


Fig. 45.

observed. In certain vessels of plants called *laticiferous*, obscure movements of granular matter have been detected. These vessels have a peculiar structure, and unite together freely, as seen in fig. 45, so as to form a sort of net-work. They are best seen in plants with milky or coloured juices, as the India-rubber and Gutta-percha plants, the

Fig. 44.—*Vallisneria spiralis*, an aquatic plant, found in ditches in the south of Europe (reduced in size.) In the separate cells movements of fluids take place. *a* Stamen-bearing plant; *b* Pistil or fruit-bearing plant.

Fig. 45.—Laticiferous vessels of the common Dandelion. The vessels unite together freely, and movements of granular matter take place.

Fig. 46.

Cow tree (fig. 46), Spurges, and Celandine. Some consider the motions in these vessels as being connected with the return of the sap from the leaves to the bark. As all the textures of which we have been treating are microscopic, it seems right that we shall now explain the structure of the microscope itself.

II.—DESCRIPTION OF THE MICROSCOPE.

49. To those who wish to study the minute structure of plants, a *Microscope* is indispensable; and it may not be out of place here to give a short notice of it. The microscope is an instrument which enables us to see objects which are placed at a very short distance from the eye, or to see very minute objects which would otherwise be invisible. In a *simple microscope* we view the object directly through a lens, or a combination of lenses. This instrument, however, does not give a large field of vision, and in using high magnifying powers

Fig. 46.—*Galactodendron utile*, or the Cow Tree of the Caraccas. It yields a white bland fluid, which is used like milk, and is contained in laticiferous vessels, which, when punctured, pour it forth in large quantity.

we approach too near the object. In very minute researches, the *compound microscope* is that which is used. This instrument is constructed on a different principle from the simple microscope. An image of the object to be examined is formed by one lens or set of lenses, and this image is viewed as an original object by the eye of the observer applied to another glass.

50. The wood-cut (fig. 47) representing a compound microscope, as constructed by Smith and Beck of London, with the accompanying diagram, will enable us to explain the nature of the instrument. It is supported on a stand A, which bears a stage-plate *d*, on which the object to be seen is placed between two pieces of glass; a mirror *b*, for throwing light upwards on the object, through a plate *c*, called a diaphragm or stop, perforated with holes of different sizes, with the view of concentrating the light more or less by excluding the outer rays coming from the mirror. The body of the microscope, *h f*, is furnished with lenses at each end; *f* is the object-glass, or that next the object on the stage, and is composed of lenses of different forms, which are rendered complete as regards light, or *achromatic*, by being formed of glass of different densities, such as crown-glass and flint-glass; *h* is the eye-piece, or the lens to which the eye of the observer is applied. The body of the instrument can be moved upwards and downwards

by the hand, as it slides in a circular brass sheath *g*—this gives what is called the coarse adjustment;

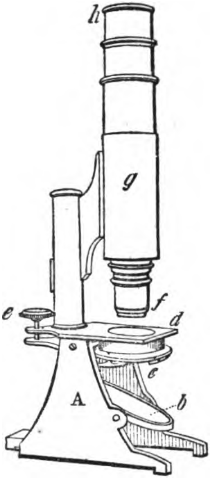


Fig. 47.

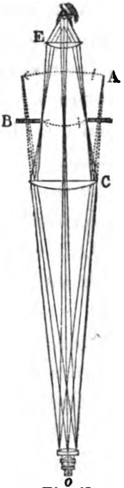


Fig. 48.

Fig. 47.—Students' Compound Microscope, as constructed by Messrs Smith and Beck. A stand, or support; *b* mirror; *c* diaphragm, or stop; *d* stage-plate for holding the object to be examined; *e* fine adjustment screw; *f* object-glass, or that next the object, achromatic —*i.e.*, not producing colour; *g* the brass sheath in which the body of the instrument is moved by the hand, so as to be adapted to the object; *h* the eye-piece, or that to which the eye of the observer is applied.

Fig. 48.—Diagram to show the principle of the compound microscope. *o* the object placed below three achromatic lenses, forming together the object-glass. Three rays of light proceeding from different parts of object reach the plano-convex lens C; and in place of going to A, so as to form an image there, are broken or refracted, so as to form an image at B, where the diaphragm is. This image is seen by the eye of the observer through the lens E. The two lenses E and C form the eye-piece.

and when it is brought near the object, it can be accurately adjusted to its proper focus by the screw *e*, which is called the fine adjustment screw.

51. This is a comparatively cheap instrument for students; and although it wants many of the conveniences connected with larger instruments, still it will answer well for the prosecution of researches into vegetable structure. In fine microscopes, the coarse adjustment, in place of being made by the hand, is accomplished by means of a rack and pinion; the stage also is moved in all directions by screws; the mirror can be moved about more freely; and the whole instrument is made so as to be placed in a horizontal position if required.

52. The diagram (fig. 48) is meant to show the action of the compound microscope. It represents the body of the instrument, with the object-glass at the lower end, composed of three compound achromatic lenses (fig. 49, *a*), each consisting of a double convex lens, made of plate or crown glass, and a plano-concave lens (fig. 49, *b*), made of flint glass. It is therefore denominated a triple achromatic object-glass, or objective. The eye-pieces at the upper extremity, consisting of two plano-convex lenses, one at

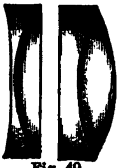


Fig. 49.

Fig. 49 represents the construction of an Achromatic Lens. *a* is an achromatic lens, consisting of a double convex lens made of plate or crown-glass, and a plano-concave made of flint glass; *b* is a section of the plano-concave lens, into which the double convex lens is fitted.

E, called the eye-glass, and the other at C, called the field-glass, with a diaphragm or dark stop at B. The object *o* is represented by a line below the object-glass. The rays of light reflected from the object, or transmitted through it from the mirror, pass through the achromatic lenses. The course of the light is marked by three rays drawn from the centre, and three from each end of the object *o*. These rays, if allowed to proceed, would form an image of the object at A; but when they reach the field-glass C, they are made to converge and meet at B, where the diaphragm is placed so as to stop all the rays except those required to form a perfect image. Thus there is a distinct image of the object at B, which is viewed as if it were an original object by the eye of the observer placed at the eye-glass E. In the compound microscope, therefore, the object is not viewed directly through a lens, or series of lenses, but an image of it is formed by one set of lenses, and this image is viewed as an original object by another lens. Bodies may be viewed through the microscope either as opaque objects, by light thrown upon them through the medium of a lens; or as transparent objects, by light transmitted through them from the mirror.

III.—ON THE GROWTH OF THE YOUNG PLANT.

53. The plant in its embryo or youngest state

consists entirely of cells. In the case of flowering plants, it is contained in the seed, and along with it there is a store of nourishment for its future growth. This nutritive matter is in some cases incorporated with the young plant, as in the bean and pea, the fleshy lobes of which are part of the young plant; in other cases it is separate from the young plant, as in the coco-nut and wheat. In figure 50 there is a representation of part of the eatable portion of the coco-nut, with the small embryo plant lying in a cavity at the top. This cavity is in the flesh of the nut, immediately below the hole in the hard shell.

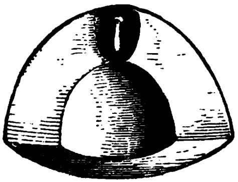


Fig. 50

The little plant weighs only a few grains, while the nourishing matter weighs many ounces. In palms generally the young plant occupies a small part of the seed, and the nourishment is abundant, although sometimes, as in the date and the ivory palm, very hard. In the grains of wheat, barley, and oats, the young plant is minute, while the starch and glutinous matter stored up along with it is large. Fig. 51 represents a grain of oats, O T being its covering, C G R the young plant,

Fig 50.—Section of part of the Coco-Nut Seed, showing the young plant in a cavity at one end, quite separate from the nourishing matter around.

with its root, stem, and leaves, and A, the mass of nourishment laid up for the use of the young plant, and not incorporated with it.

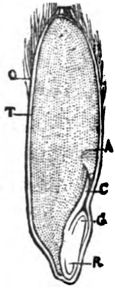


Fig. 51.

54. When the seed is placed in favourable circumstances, the little plant begins to sprout or germinate. In order that this process may take place, it is necessary that moisture, heat, and air should be present, and it is also important that the plant at first should be excluded from direct light. The supply of these requisites must be properly regulated, and in doing so the nature of the soil must be attended to. One of the most important operations for enabling grain to grow and give abundant produce is draining. Undrained soil from having much moisture is cold, is deficient in the supply of air, and prevents the constant renewal of food to the roots. Draining carries away superabundant moisture, allows a constant supply of fresh fluid nourishment to penetrate through the soil at the roots, permits the access of air and heat, and thus materially contributes to the health and vigour of the crops. The soil must therefore be prepared and fitted for the seed, otherwise, as far as regards useful and nutritious plants, the sow-

Fig. 51.—Grain of Oats (*Avena sativa*). O T, its covering; C G R, young plant; A, store of nourishment.

ing will be unproductive. "Man must gain his bread by the sweat of his brow."—(Gen. iii. 19.) The garden of the sluggard no doubt produces plants, but they are not such as are fitted for the nourishment of man. "I went by the field of the slothful; and, lo, it was all grown over with thorns, and nettles had covered the face thereof."—(Prov. xxiv. 30, 31.) As the sluggard will not plough, he shall beg in harvest and have nothing.—(Prov. xx. 4.)

55. When seeds are sown naturally, they have only a slight covering of soil, and if they happen to become deeply buried, the proper access of air is prevented, and their sprouting is retarded. It is of importance that man in sowing seeds should imitate what occurs in nature. They should be placed at a moderate and equal depth. Hence the necessity for regular ploughing, in order that all the grains may be at a proper distance from the surface of the soil, and that the growth and progress of the plants may be uniform. When ploughing is irregular, the grain sinks to different depths, some plants come up before others, and they ripen at different periods,—an occurrence which tends to injure the harvest; for the ripe grain when allowed to remain beyond a certain period loses part of its nutritious qualities, and thus the produce of the field is diminished in value. Seeds often lie long dormant, especially when placed too deep

in the earth, and it is only when the soil is turned up and air admitted that they spring up. Many are the instances of seeds retaining vitality long, when buried in the ground, under certain conditions. The seeds of white clover may remain in the soil for many years, and yet when brought near the surface so as to be within the action of the air germinate freely. After the great fire of London, numerous plants sprung up, the seeds of which would appear to have lain long in the ground. While seeds naturally preserved in the soil and in peat mosses retain their vitality, it is not easy for man to imitate these conditions. All the stories about the germination of mummy-wheat are doubtful. There does not appear to be a single authentic case of such an occurrence having taken place. No doubt there are numerous fields of what is called mummy-wheat over the country, but none can be proved by unimpeachable evidence to be the produce of grains of the same age as the mummies.

56. The various phenomena connected with the sprouting of the seed are well seen in the malting of barley. The grain is exposed to moisture, heat, air, and is kept in comparative darkness. It is precisely in circumstances fitted for its sprouting, or *germination*, as it is called. A very marked change takes place in the contents of the grain. The starch, which is insoluble in water, and unfit

for the nourishment of the plant, is converted into sugar, which is soluble, and easily taken up by the cells of the plant as food. The young roots are first protruded, and then the stem rises, surrounded by a leaf called a cotyledon, or seed-leaf. If the

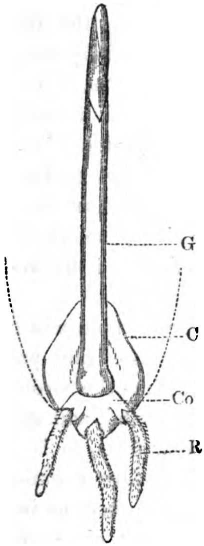


Fig. 52.

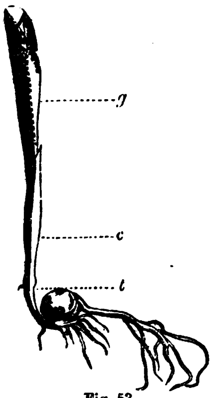


Fig. 53.

Fig. 52.—Germination or sprouting of the grain of oats. R, roots passing through sheaths Co; C, cotyledon; G, the first leaves of the plant. The plant is monocotyledonous.

Fig. 53.—Germination or sprouting of the grain of maize, or Indian corn. *t*, stalk supporting the cotyledon *c*; *g*, the first leaves of the plant. It is monocotyledonous.

barley were allowed to grow, the whole of the sugar would be used by the plant. But man wishes to get the sugar, and he therefore stops the plant in its growth by drying it, and thus makes malt. The progress of growth in the oat is seen in fig. 52, which represents the embryo at one end of the grain, the curved dotted lines marking the dimensions of the grain. The letter R indicates the young roots passing through sheaths, Co, and covered with little cellular hairs, ready to take up fluid nourishment; C is the cotyledon—*i.e.*, the seed-lobe or seed-leaf; G is the young stalk or stem rising upwards. In the Indian corn (fig. 53) the same parts are seen—the roots, the cotyledon *c* united to the grain by a stalk *t*, and the young stem-leaves *g*.

57. In many plants, the embryo, in place of having only one cotyledon, as in grasses and palms, has two. These cotyledons, during the sprouting of the plant, either rise above ground, and appear as temporary leaves of a peculiar form, as is seen in the lupin; or they remain below ground as fleshy lobes, and are gradually absorbed, as in the bean. In fig. 54, a representation is given of the germination of the common haricot, where R is the root of the young plant, T is the stalk supporting the two cotyledons, C C; and G G are the first proper leaves of the plant. In the orange (fig. 55), the cotyledons C remain below ground in the seed

T; such is also the case in the bean and pea, in which the cotyledons form the great bulk of the

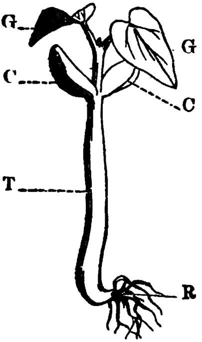


Fig. 54.

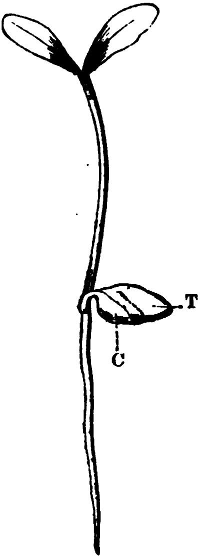


Fig. 55.

seed. In plants which have no flowers, as ferns, mosses, sea-weeds, and fungi, the little germs are

Fig. 54.—Germination or sprouting of the haricot. R, roots; T, stalk supporting two cotyledons, C C; G G, the first leaves. The plant is dicotyledonous.

Fig. 55.—Germination or sprouting of the orange. C, the two cotyledons enclosed in the seed T, and remaining underground. The plant is dicotyledonous.

simple cells without any cotyledon, which seem to send out roots from various parts of their surface. In fig. 56 there is a representation of the germ of a flowerless plant, consisting of a cell, V, with little processes, C, called cilia, which exhibit movements for a limited period before the germ sprouts.

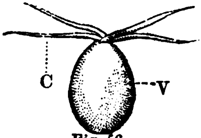


Fig. 56.

There are here no distinctions of parts, as in the embryo or germ of flowering plants. It will thus be seen that, according to the nature of the embryo or young plant, the whole vegetable kingdom can be divided into—1, flowering plants having one cotyledon, called Monocotyledonous plants (figs. 52, 53); 2, flowering plants having two cotyledons, or Dicotyledonous plants (figs. 54, 55); 3, flowerless plants without cotyledons, Acotyledonous plants (fig. 56.)

58. Many are the illustrations in the Bible taken from the sowing and springing of the seed, and from the nature of the soil on which it falls. The seed of the Word must be sown in good soil, prepared by the Great Husbandman; and when watered by the dew of His Spirit, it springs up and bears fruit to the glory of God. The growth is slow and gradual, "first the blade, then the ear,

Fig. 56.—Germ or spore of an acotyledonous flowerless plant (*Chætophora*), consisting of a cell V, with peculiar moving processes C, called cilia.

then the full corn in the ear."—(Mark iv. 28.) It may lie dormant for a time, and in darkness, but the spark of life will ultimately break forth. In the parable of the sower (Matt. xiii. 3; Mark iv. 3; Luke viii. 5), the various kinds of soil are employed to illustrate the heart of man in its natural and in its renewed state. In the former, it is hard and cold, and is not prepared for the good seed: the seed does not sink into it, or it is choked by weeds, or it lacks the dews and the atmosphere of heaven; and hence it brings no fruit to perfection. In the latter, there is the preparation of the Spirit, nourishment from on high, the former and the latter rain, and fruit, in some thirty, in some sixty, and in some an hundredfold. The former and the latter rain are often referred to as promoting the sprouting of the seed and the growth of the plant. —(Jer. v. 24; Hos. vi. 3; Joel ii. 23). The first of these rains took place in Palestine after the seed was sown, and the second when the corn was nearly ripe and harvest was at hand. So it is with the Christian life. Sometimes, just after the seed of eternal life is sown in the hearts of young converts, they are favoured with joyful and refreshing seasons of love and peace. Others experience the most plentiful showers of heart-reviving love just as the sickle is to cut them down, that they may be gathered into the heavenly garner.

59. In John xii. 24, Christ says, "Except a

corn of wheat die, it abideth alone: but if it die, it bringeth forth much fruit." We see an apt illustration here. The great bulk of the grain of

Fig. 57.

wheat (fig. 57) is composed of nutritious matter, separate from the little plant or embryo (fig. 58.) This matter must all be changed and dissolved,

Fig. 58.

in order that the plant may spring. Unless it dies, and undergoes solution, there can be no nourishment conveyed. Again, the sprouting of the grain is taken by St Paul as an emblem of the resurrection. That which is sown is not quickened except it die; and out of the corruption and dissolution which it undergoes there springs up, by a wondrous metamorphosis, wheat, or some other grain. "So also is the resurrection of the dead; it is sown in corruption, it is raised in incorruption: it is sown in dishonour, it is raised in glory: it is sown in weakness, it is raised in power: it is sown a natural body, it is raised a spiritual body." —(1 Cor. xv. 42–44.)

> "Christ out of ruin brings forth strength and beauty;
> Yea, life and immortality from death."

In Matt. vi. 28, our Saviour says, "Consider the lilies how they grow." We fear this is not often

Fig. 57.—Grain of wheat, seen on its inner surface.

Fig. 58.—Grain of wheat, seen on its outer surface, with the small embryo at one side; all the rest of the grain being occupied with nourishing matter, which is dissolved, and dies.

done. We are content to look at the plant when grown, but we do not examine *how* they grow, from the embryo up to the perfect state of flowering and fruiting. We shall understand the illustration better, and see more of the providential care of God, if we attend to the development of cell after cell by slow degrees, the formation of vessels, the arrangement of coloured cells, the absorption of fluids, and the various processes of nutrition and reproduction.

60. In Ps. xcvii. 11, it is said, "Light is sown for the righteous, and gladness for the upright in heart." Here light and gladness are regarded as seeds sown in the earth for the righteous. Let us trace out the illustration by reference to the phenomena connected with the sowing of seed. As in the case of the seed, light and gladness are placed in the earth. They are much obscured by the earthy covering: light is mixed with darkness, as it were, and gladness with sorrow. The believer sees through a glass darkly, and has many tears and woes. But light and gladness are there, and will spring up. The more slightly they are covered by the earth and the things of the earth, the more readily will they develop themselves. If they are deep in the earth, their progress is hindered; they require the atmosphere of heaven to bring them out. "Who is he that walketh in darkness, and hath no light; let him trust in the

name of the Lord, and stay himself upon his God." (Isa. l. 10.) This is but the sowing time; at eventime there shall be light. Then shall light and gladness, freed from earth and all its encumbrances,

Fig. 59

spring up in bright effulgence and fulness of joy, and the seed sown in earth shall expand in all the blossoms and fruits of heaven.

61. The sowing of the seed in the mud of rivers may perhaps be alluded to in the following words: "Cast thy bread upon the waters, for thou shalt

Fig. 59.—*Nymphæa Lotus*, one of the plants to which the name of Lotus was given by the ancients. Its seeds were used to form bread, and its roots are also eaten. It is considered to be the lily of the Old Testament.

find it after many days."—(Eccles. xi. 1.) The seeds of the Egyptian Lotus (fig. 59), a kind of water-lily, are used in the manufacture of bread, owing to the quantity of starch and gluten which they contain. These seeds are sown by being enveloped in clay,

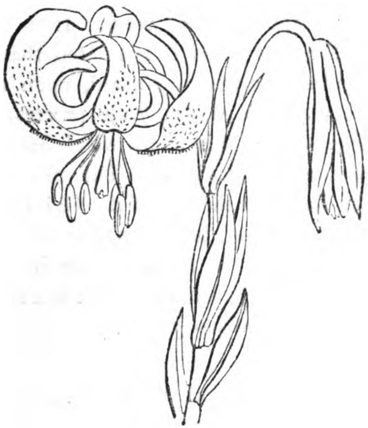


Fig. 60.

and thrown into the water, so that they sink in the mud.* There they germinate; and, after many

Fig. 60.—*Lilium Chalcedonicum,* the scarlet martagon lily. The lilies of the field of the New Testament.

* This mode of sowing, according to Royle, is to the present day practised by certain tribes in the Indian peninsula. For an interesting and popular account of the Lotus and allied plants, see Mr G. Lawson's work "On the Royal Water-Lily of South America, and the Water-Lilies of our own Land."

days, the plants appear above the water, bearing flowers and fruit, the seeds of which are again employed as bread. These water-lilies used to abound in the Nile, and they are not uncommon in eastern countries. Mr Lawson, in speaking of this plant, says: "It is a famous plant in ancient history, and known under the name of *Lotus*. It is still held sacred in the East; and it is related that one of the benighted natives of Nepaul, upon entering Sir William Jones's study, made prostrations before the flowers of this plant, which happened to lie there for examination." The plant is considered by Royle as the lily of the Old Testament, so frequently referred to in the Song of Solomon· while the lilies of the field, noticed in the New Testament, are probably the scarlet martagon lily, or *Lilium Chalcedonicum* (fig. 60.)

IV.—ON THE STRUCTURE AND FUNCTIONS OF THE ROOT.

62. The root is the first part of the young plant which protrudes from the seed. It descends into the ground in order to fix the plant and to derive nourishment. On account of its downward tendency, the name of Descending Axis is sometimes applied to it. The cells situated near the extremities of the minute fibrils of the root, are those which are chiefly concerned in taking up nourishment

from the soil. They are represented on a magnified scale in fig. 61, SP. The other cells of the root are indicated by CC, and these pass gradually into dotted vessels FP. As plants are fixed to a spot, their food must be always within reach; and it is requisite that the roots should have the power of spreading, so as to secure renewed supplies of nutriment. A beautiful provision is made for this by the elongation of the roots taking place at their extremities, so that their advancing points are enabled easily to accommodate themselves to the nature of the soil in which the plant grows. If roots had increased by additions throughout their whole extent in the same way as stems, they would, in many instances, when meeting with an impenetrable soil, have been twisted in such a way as to unfit them for the free transmission of fluid. But by the mode of lengthening at the point, they insinu-

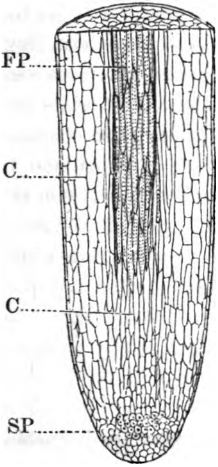


Fig. 61.

Fig. 61.—Vertical section of a rootlet of an orchis, much magnified. SP, the minute cells at the extremity, called spongelets; CC, the other cells of the root; FP, dotted vessels.

ate themselves easily into the yielding part of the soil, and when obstacles are presented to their progress they wind round about them, until they reach a less-resisting medium. They are thus also enabled to move from one part of the soil to another, according as the nourishment is exhausted.

63. The root, in its growth, keeps pace with the development of the stem and its branches. As the stem shoots upwards and developes its leaves, from which water is constantly transpired, the roots continue to spread, and to renew the delicate cells and fibrils which absorb the fluid required to compensate for that lost by evaporation, or consumed in growth. There is a constant relation between the horizontal extension of the branches and the lateral spreading of the roots. In this way the rain which falls on a tree drops from the branches on that part of the soil which is situated immediately above the absorbing fibrils of the roots. It is not by watering a tree close to the trunk that it will be kept in vigour, but by applying the water on the soil at the part corresponding to the ends of the branches. "We have here," says Roget, "a striking instance of that beautiful correspondence which has been established between processes belonging to different departments of nature, and which are made to concur in the production of such remote effects as could never have been accomplished without these preconcerted and harmonious adjustments."

If the roots are not allowed to extend freely, they exhaust the soil around them, and are prevented from receiving a sufficient supply of food. The plants in such a case, deprived of their proper means of support, become stunted and deformed in their appearance.

64. If we wish trees to be firmly rooted, we must allow the branches to spread freely. When they are so planted that the branches and leaves of contiguous trees do not interfere with each other, and thus all parts are exposed to air and light equally, the roots spread vigorously and extensively, so as to fix the plants firmly in the soil, and to draw up copious supplies of nourishment. But in crowded plantations, where the branches are not allowed freedom of growth and exposure, and the leaf-buds are consequently either arrested or feebly developed, the roots also are of necessity injured. They do not spread, and the trees are liable to be blown over by the wind; they exhaust the soil in their vicinity, circumscribed by the roots of the trees around; their functions become languid, and thus they react on the stem and branches, so that the additions to the wood are small, and the timber is of bad quality. In such a plantation, we may see a marked difference between the trees on the outside and those in the centre; the former having their branches and leaves fully exposed on one side, grow with comparative vigour, and form ex-

cellent timber on that side of the stem where light and air are admitted; while the latter, hemmed in on all sides, are *drawn up* like bare poles, producing a small amount of ill-conditioned wood. A crowded plantation, in which the trees are allowed to increase in size, until they interfere with each other, cannot be easily reclaimed; and every attempt at thinning is accompanied with the risk of exposure to the blasts, which speedily level trees having no firm hold of the soil.

65. The roots of plants should not be disturbed at the time when they are in active operation. During the season of growth, when the branches and leaves are pushing forth, the roots are also developing their rootlets, and constantly renewing their delicate absorbing extremities. Any attempt to transplant at this period is attended with serious injury, because those minute fibrils are destroyed by means of which the fluid transpired by the leaves is restored. It is only in autumn, when the rootlets cease to grow, and absorption becomes languid, or in early spring before their activity begins, that transplanting can be prudently conducted. In transplanting large trees it has been customary to cut the roots all round at some distance from the trunk, the season before they are removed. Thus an opportunity is afforded for the production of new fibrils, which, after transplantation, are ready to absorb nourishment.

66. Roots in general descend into the soil at once, but in some cases they proceed from different parts of the stem, and thus are in the first instance aerial. The Banyan tree of India (fig. 12, p. 32), exhibits these roots in a remarkable manner. They proceed from all parts of its stem and branches, and ultimately reach the soil, forming numerous stems which support this wide-spreading tree. The famous Nerbudda Banyan has 300 large and 3000 small stems, and it is said to be capable of sheltering 7000 men.

> "Such, too, the Indian fig, that built itself
> Into a sylvan temple, arch'd aloof
> With airy aisles and living colonnades."

The Screw-pine (fig. 2, *b*, p. 18), is another instance of a plant giving out aerial roots. These support the plant like wooden props. A large tree of this kind in the Palm House of the Edinburgh Botanical Garden, had one of its branches injured many years ago, and at the point of injury a root appeared long before its time, and thus supported a branch which would otherwise have been cut off. This circumstance is mentioned by Miss M'Nab in her Lessons from Bible Plants, as having struck Dr Chalmers very forcibly on one of his visits to the garden.*

67. When roots do not extend much, they are sometimes provided with reservoirs of nourish-

* Botany of the Bible, by Miss M'Nab.

ment which supply the means of growth during a certain period. This is seen in the case of terrestrial orchids (fig. 62). These reservoirs or tubercules constitute the salep of the Turks, which is used as food. In the orchids of warm climates, in place of

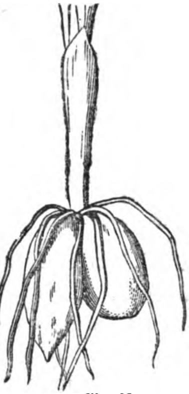


Fig. 62.

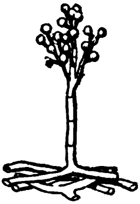


Fig. 63.

these roots, there are large thickened bulb-like stems which serve the same purpose (fig. 14, p. 33). Some plants send their roots or suckers into

Fig. 62.—Roots of Orchis; some of them are slender and absorb nutriment, while two of them are thick, fleshy tubercules which contain a reservoir of food, and constitute salep.

Fig. 63.—A species of mould-fungus (*Botrytis*), magnified. There are below root-like filaments constituting the spawn. These insinuate themselves into the tissues of living plants and act as parasites, drawing nourishment from the tissues, and ultimately destroying the plants. The stalk consists of cells bearing rounded reproductive cells or spores.

the substance of other plants either dead or living, and derive their food entirely from them. Such are called *parasites*, and they may be illustrated in the case of moulds (fig. 63) and fungi growing on the decaying stumps of trees, and causing diseases in corn and other plants—dodder, which injures flax and clover by living on their juices, broom-rapes, and scale-wort. These parasites have either no leaves or only brown scales on their stems; others, as the mistleto, have green leaves, which alter the juices taken from the stock by exposure to the air and light. The study of the growth of parasitic fungi is a subject of great importance, as many diseases in plants, animals, and man appear to be either caused or modified by them. Dry-rot in wood, for instance, is attributed to the attack of a fungus, so also are certain diseases of the skin and mucous membrane in man and animals.

68. The root supplies many Scripture illustrations, both as fixing the plant and as drawing up nourishment. Thus in Hosea xiv. 5, Israel when restored, is said to "cast forth his roots as Lebanon," or the cedar of Lebanon, implying great vigour as well as firmness and strength. This tree (fig. 73, p. 94), is remarkable for its spreading roots, which extend to a great distance from the trunk, thus bearing a relation to the enormous branches. These roots fix the tree very firmly in the soil or rock, and enable it to derive a constant supply of

nourishment. The streams from Lebanon furnished water to the cedar, and hence Ezekiel, when likening the Assyrian to this tree (xxxi. 4, 5), says, that the waters made him great, and that his branches became long because of the multitude of waters. The believer is "rooted and grounded in love" (Eph. iii. 17), his roots extend into the Rock of Ages (Col. ii. 7), he is watered by the dew of God's Spirit (Hos. xiv. 5), and thus it is that his root is not rottenness, nor does his blossom go up as dust (Isa. v. 24), but he brings forth fruit to the glory of God. The root being holy, so are the branches (Rom. xi. 16.) If there is no root, if, with a specious appearance, the man grows up, like the trees of a crowded forest, under an adventitious support from his fellow-men, then when mere human props are removed, there is nothing to prevent him from falling. He may be drawn up as it were, under the fostering care of others, and may be loud in his profession, attaining to great eminence in the world, but if the root of the matter (Job xix. 28) is not in him, then all will be ruin at last. Such an one hath no root, and dureth only for a while; but when tribulation and persecution ariseth because of the word, or when temptation comes, he falls away.—(Luke viii. 13; Mark iv. 17; Matt. xiii. 21.) As being the source of life to his Church, Christ is sometimes likened to the root. Thus, in describing the blessedness of the latter

days, Isaiah says (xi. 10), "And in that day there shall be a root of Jesse, which shall stand for an ensign to the people; to it shall the Gentiles seek; and his rest shall be glorious." In Revelations v. 5, He is called the root of David. Though at first He was despised and rejected by men, as a root out of a dry ground (Isa. liii. 2), yet as the tree whose leaves are for the healing of the nations (Rev. xxii. 2), He shall overshadow the world, having the uttermost parts of the earth for His possession.—(Ps. ii. 8.)

V.—ON THE STRUCTURE, CONFORMATION, AND FUNCTIONS OF THE STEM.

69. The stem is the name given to that part of a plant which bears the leaves and the flowers. Some plants have very short and inconspicuous stems; others have long and conspicuous stems. In the cowslip, dandelion, and gentianella, the stem is so short that the leaves appear to arise from the root. Some stems lie along the ground as in the iris; others are completely under ground. The latter give off leaf-buds which appear above ground. The banana has an under-ground stem pushing out shoots which form temporary aerial stems or branches; so have also the asparagus, the bamboo, ginger, arrow-root, and some rushes. Many subterranean stems are called, in common language,

roots, from which, however, they are distinguished by the leaf-buds which spring from them. Thus the potato is an under-ground stem or branch giving off buds in the form of *eyes*. The bulbs of lilies, tulips, crocuses, meadow-saffron, are in reality stems giving off buds, which are covered with scales, or modified leaves.

70. Some stems die annually, others continue permanent. Of the permanent woody stems there are two marked kinds. One occurs in the trees of temperate climates generally, and is recognised on a transverse section, by the appearance of numerous woody circles with rays passing from the pith to the bark, which is separable. This is well seen in

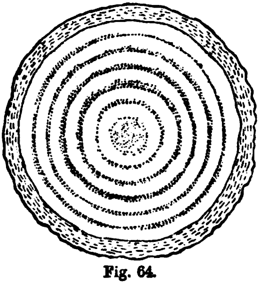


Fig. 64.

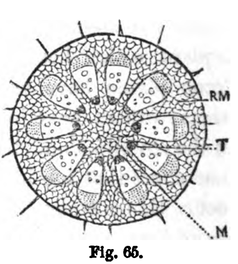


Fig. 65.

the common oak (fig. 64), where the pith in the

Fig. 64.—Tranverse section of the stem of an oak six years old, *i.e.*, having six concentric woody circles; cellular pith in the centre, surrounded by spiral vessels, and woody layers consisting of woody tubes and porous vessels, layers of bark both cellular and fibrous on the outside.

Fig. 65.—Section of an Exogen, during its first year of growth; M,

centre is composed of cells; the circles of wood consist of woody fibres (fig. 32, p. 50), and dotted or porous vessels (fig. 34, p. 51); cellular rays extend from the pith to the bark, which is partly fibrous and partly cellular. A section of such a stem in the first year of growth exhibits the appearance presented in fig. 65, where M, is the cellular pith, very large; RM, large cellular rays proceeding from the pith and ending in the cellular bark, which forms the circumference. These rays divide the stem in the figure into ten wedges of woody and porous vessels; while spiral vessels T, occur round the pith. In the second year of growth, a second set of vascular wedges are formed outside the first circle, and so on year after year, the stem increasing in diameter by circles of wood on the outside of those previously formed. The new wood is on the outside, the old wood within. Such trees are hence called outside-growers or *Exogens*, and they have their hard-wood in the inside, their soft-wood on the outside.

71. The structure of the different parts of such a stem is represented in fig. 66, where A is a transverse section, and B is a longitudinal one, of

cellular pith, very large and occupying a considerable part of the stem; T, spiral vessels forming a layer round the pith; RM, large cellular rays joining the pith and bark, which is represented by cells on the circumference. The woody and porous vessels are placed between the pith and the bark, and are divided into ten wedges by the rays.

the stem of a maple one year old. In these figures, T indicates the spiral vessels round the cellular pith; VP are porous vessels, having large round apertures (fig. 34, p. 51); F, woody fibres (fig. 32, p. 50); C, a layer of cells between the wood and the bark, which is composed of cells S and Pc, and of fibres F. A stem of maple, three years old, is given in fig. 67. Taking the woody part of the stem, we find that during the first year (1) there is the cellular pith, M; spiral v ssels, T; porous or dotted vessels, V; and woody fibres, F. In the second year (2) there are seen dotted vessels,

A

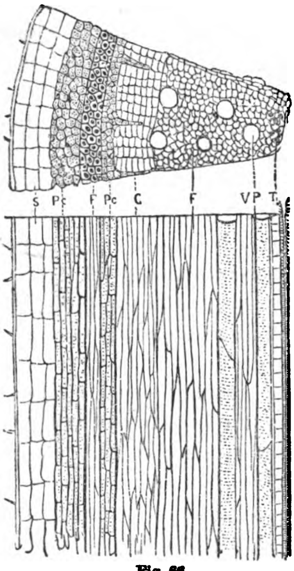


Fig. 66. B

Fig. 66.—Stem of a maple at the commencement of its second year of growth. A, transverse or horizontal section; B, longitudinal or perpendicular section; T, spiral vessels round the pith; VP, porous vessels, with large apertures; F, woody fibres; C, layer of cells between bark and wood; Pc, Pc, inner cellular portion of bark separated by woody fibres of the bark, F; S, outer cellular corky layer of bark.

V; and woody fibres, F. So also in the third year (3). A layer of cells between the wood and bark is marked C. The outer bark, sometimes of a corky nature, as in cork oak, is marked S; and

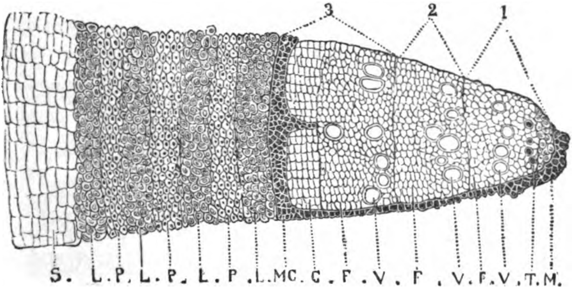


Fig. 67.

below it are different layers of bark, composed of woody fibres, L, and cells, P; while next the newest woody cells, C, there is a cellular layer connected with the bark, marked M C.

72. The woody tubes in cone-bearing trees, as fir, spruce, larch, cedar, cypress, and araucaria, exhibit markings called discs, composed, as it were, of a circle and a dot in the centre. Sometimes these discs are in single rows, as in fig. 68; in

Fig. 67.—Transverse section of a maple three years old, 1, 2, 3, being the woody growth of each year, the layers of bark extending from S to M C. The pith is marked M; spiral fibres, T; porous vessels, V; woody fibres, F; layer of new woody cells, C; layer of new bark cells, M C; inner woody fibres of bark, L; cellular layer of bark, P; outer corky bark, S.

others they are in double or triple rows, as in figs. 69 and 70. When the rows are more than one,

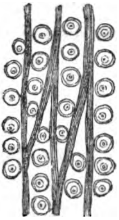


Fig. 68.

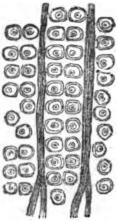


Fig. 69.

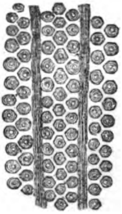


Fig. 70.

they are arranged in parallel series, the discs being either opposite to each other, as in firs (fig. 69), or alternate with each other, as in Araucaria and Altingia (fig. 70). One of these latter plants, Altingia excelsa, or Norfolk Island pine, is represented in fig. 71, from a specimen grown in the Botanic Garden, the wood-cut of which was kindly contributed by Hugh Miller, Esq. The plant is interesting, on account of the markings in its wood, as well as from the fact that plants allied to it are now found in Britain in a fossil state, for instance, at Craigleith quarry.

73. From the mode of growth in exogenous

Figs. 68, 69, 70, were taken from specimens, kindly furnished by Mr Nicol, who has been long celebrated as having led the way in sections of fossil woods, and whose collection of microscopic sections of wood is unrivalled. 68, woody tubes of fir, with single rows of discs; 69, woody tubes of fir, with double rows of discs, which are opposite to each other; 70, woody tubes of *Altingia excelsa*, with double and triple rows of discs, which are alternate.

trees, it is obvious that we can ascertain the age of the tree by counting the number of woody circles.

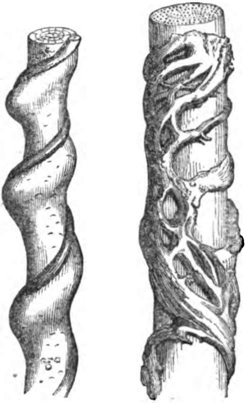
Fig. 71.

Thus, in fig. 64, p. 86, the oak is six years old. This calculation can be made with tolerable correctness in trees of temperate and cold climates, where during the winter there is a marked interruption to growth, and thus a line of demarcation is formed between the circles; but in trees of warm climates, this mode of estimating age may lead into error. It would appear that in these there are often the appearance of numerous circles in one year. The age of 5000 years, attributed to some baobabs (fig. 11, p. 31) in Senegal, may be accounted for in this way. Even in the trees of this country, when they get old, it is found that the different circles are so blended as to make it difficult to count them accurately.

74. The wood in the centre of exogens is often altered in colour, by peculiar coloured woody matter

Fig. 71.—Specimen of *Altingia excelsa*, or Norfolk Island pine, in the Botanic Garden of Edinburgh. (Communicated by Hugh Miller, Esq.)

being deposited in the tubes. Thus the heart-wood of the ebony tree is black, and that of the oak deep brown, while that of the outer soft wood is pale. The latter is the part in which the active processes of life go on; and hence, if it is destroyed, the plant dies. A woody plant, such as honeysuckle, or some Bauhinias of foreign countries, twining round the stems of such trees, cause strangulation, in consequence of the mode of their growth, by external addition; and in process of time, if the woody climber is sufficiently strong, and does not break or yield, the vessels of the soft wood are impeded in their growth, and the tree will ultimately be destroyed. In fig. 72, A, a twining plant, called the *bush-rope* in the West Indies, is seen causing contractions of the stem. Sometimes grooved sticks are formed in the same



A Fig. 72. B

Fig. 72.—The effects of twining plants in different stems. A, the Bush-rope, a climbing-plant, twining round the stem of an Exogen, and causing strangulation; B, a Bauhinia, or woody-climber, twining round the stem of an Endogen (a palm), and not causing any strangulation.

way in Britain, by the twining of the honeysuckle round neighbouring trees.

75. Exogenous trees give a character to the landscape of the countries in which they abound. They have large trunks, which produce numerous branches, spreading in all directions. The trunk tapers as it ascends, and the branches become thinner towards their extremities. The mode in which the branches spread, and their comparative lengths, give rise to differences in the contour of exogenous trees. When the lower branches are largest, and they gradually diminish in length upwards, the trees are more or less pyramidal; when the reverse takes place, they have an umbrella-like top. The Cedar of Lebanon (fig. 73)—a tree often referred to in Scripture—will serve as an illustration of an exogen. In early times it appears to have grown abundantly in Lebanon, and to have formed its distinguishing feature. In later times there has been a great diminution in the number of cedars in Lebanon; so that, in 1832, there were only seven remaining, most of them apparently of a great age. The cedar is a wide-spreading evergreen tree, from fifty to sixty feet high, with a large trunk, numerous large and long branches, which extend in a horizontal manner, nearly at right angles from the trunk, and with their evergreen leaves form a spacious shady covering. It is not liable to the attacks of climbing-

plants. How beautifully does the prophet describe the character of the cedar, when he speaks of its high stature, its top among the thick boughs, its multiplied boughs, its long branches, and its shadowing shroud.—(Exek. xxxi. 3–7.) It was pre-eminently distinguished by its exalted growth. It

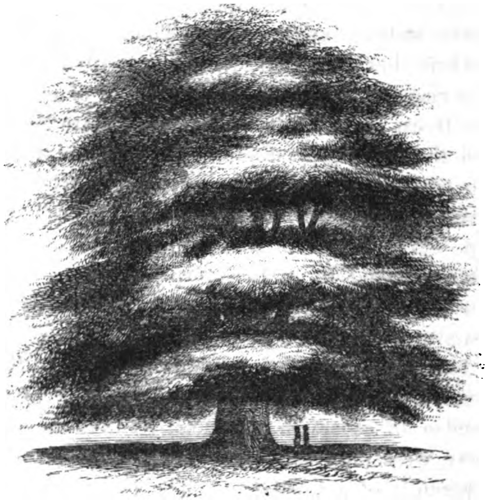


Fig. 73.

is said in 1 Kings iv. 33, that Solomon "spake of trees, from the cedar-tree that is in Lebanon (as being the most conspicuous and noble), even unto

Fig. 73.—*Cedrus Libani*, the Cedar of Lebanon, an exogenous tree, with a thick trunk and spreading branches.

the hyssop which springeth out of the wall." It is also spoken of as "the glory of Lebanon" (Isa. xxxv. 2; lx. 13); and the abundance of its fruit or cones is noticed in Ps. lxxii. 16. The strength and durability of the tree was a subject of common remark; and the Psalmist emphatically describes the power of the Lord when he says, "The voice of the Lord breaketh the cedars; yea, the Lord breaketh the cedars of Lebanon."—(Ps. xxix. 5.) In Ps. xcii. 12, the righteous man is represented as growing like a cedar in Lebanon; in Numb. xxiv. 6, the people of God are likened by the wicked prophet to cedar-trees beside the waters; and in Ps. lxxx. 8–11, Israel is spoken of as sending out her boughs like the goodly cedars. How well do these figures picture the believer's growth in grace. He is like a goodly and excellent cedar (Song of Sol. v. 15), vigorous and evergreen, showing forth the power and glory of God, fixed in the Rock of Ages, whence are all his well-springs, which refresh and invigorate him even as a well of living waters and streams from Lebanon. —(Song of Sol. iv. 15.)

76. In Palms, and certain trees of warm climates, a stem of a totally different kind is seen. In them the increase of growth is by additions of woody and porous vessels towards the centre. The stem is at first entirely cellular, but in the progress of growth, bundles of vessels are formed among the

cells. These gradually increase and distend the stem to a certain amount the first year. Next year new bundles are produced inside the last, which increase the diameter still more, until at length by successive additions the stem is distended to the utmost. The outer portion becomes hard, so as sometimes to resist the blow of a hatchet, while the inner part is comparatively soft. This woody growth has given rise to the name of inside growers or *Endogens*, applied to plants having stems of this kind. On making a section of a palm stem, the appearance presented is seen in fig. 74.

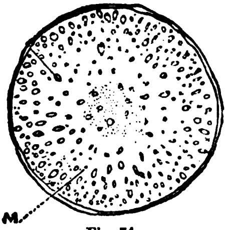


Fig. 74.

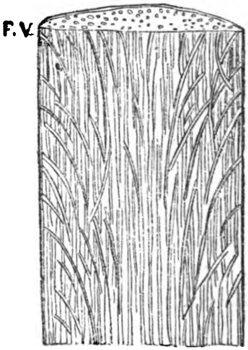


Fig. 75.

Fig. 74.—Transverse section of a palm stem, showing endogenous structure. Cellular tissue, M; bundles of woody and other vessels, F. No concentric circles, no rays.

Fig. 75.—Longitudinal section of a palm stem. Woody fibres, FV, descending in an oblique manner, and interlacing.

There is no distinct pith, no concentric circles, no rays, no separable bark. The outer part representing the bark is hard, and is incorporated with the woody fibres below. The interior consists of cells *M*, in which bundles of vessels *F*, are dispersed irregularly. In tracing the vessels *FV*, in the vertical section of a palm (fig. 75,) it is found that they follow a curved course, and interlace with each other. Palms have straight trunks of nearly equal diameter throughout, bearing a cluster of leaves at the summit. This character is seen in fig. 2, *a*, p. 18, and in fig. 18, p. 35. They rarely branch, and grow chiefly in height, not much in diameter. The age of a palm may be ascertained by measuring its height, for it is found that the growth in an upward direction is pretty nearly uniform in each species. From the small increase in diameter, and the hardness of the exterior, a twining woody plant does not injure a palm-stem. In fig. 72, B, p. 92, is seen a palm-stem with a woody bauhinia twisting round it, without affecting its growth. When the tuft of leaves at the summit of a palm is completely destroyed, the plant dies, because there is no provision for lateral buds, as in our trees. Williams the missionary relates, that in the South Sea Islands they destroy the coco-nut trees in this manner.

77. Palms give a marked and distinctive character to the vegetation of tropical regions, and their

umbrageous foliage, particularly in the case of those with fan-shaped leaves, affords an excellent shelter from the sun's rays. In figs. 76, 77, 78, and 79 are represented the Wax Palm of South

Fig. 76.

Fig. 77.

America, the Oil-giving Palm of Guinea, the Cabbage Palm or Mountain Cabbage of the West Indies, and the Fan Palm of the East Indies. In all of these, we remark the erect growth, the bare un-

Fig. 76.—*Ceroxylon Andicola,* the Wax Palm. Its trunk furnishes a waxy secretion.

Fig. 77.—*Elais Guineensis,* the Palm which furnishes palm oil.

branched stem of nearly uniform diameter through-

Fig. 78.

Fig. 79.

out, and the crown of leaves at the summit, from which the flowering stems and fruit proceed.

78. Many palms yield edible fruits, containing a great quantity of oil or fatty matter. Humboldt says that they yield wine, oil, wax, flour, sugar, thread, utensils, weapons, food, and habitations. The Date Palm (fig. 18, p. 35), is that referred to in the Bible. The Coco-nut Palm (fig. 2, *a*, p. 18), is put to many important uses; its root is chewed,

Fig. 78.—*Euterpe montana*, Cabbage Palm. The flowering stalk is used as food, and so is the young bud.

Fig. 79.—*Corypha umbraculifera*, the Fan Palm. It has large fan-shaped leaves.

the fibrous matter surrounding its leaves is used for cloth and for sails; its stem is employed for building and making spears, the wood is imported under the name of porcupine wood; its leaf-bud is used as an article of food like cabbage; its leaves are used to thatch houses, to make baskets, lanterns, carpets, bonnets, paper; the midrib of the leaf is used for oars and paddles, the husk of the fruit is used for cordage, the hard shell for cups and basons, the kernel for food and for giving oil; and the flower-stalk yields a sweet juice which is fermented.

79. In Psalm xcii. 12, the Psalmist says, that "the righteous shall flourish like the palm tree." To those who inhabited Palestine, the illustration would lead them to contemplate the straight and erect growth of the tree, its unbranched and unencumbered stem, and the beauteous crown of leaves at its summit. It would also recal to their minds that the palm flourished in the desert, and that its presence there always indicated moisture, which enabled it to flourish amidst surrounding barrenness. In Exod. xv. 27, it is said that the children of Israel "came to Elim, where were twelve wells of water, and threescore and ten palm trees." The believer's growth, like that of the palm, is internal and unseen by the world. His age is determined by his nearness to heaven. His stature, as Solomon says, is like the palm tree (Cant. vii. 7),

and he grows up to the measure of the stature of the fulness of Christ.—(Eph. iv. 13.) He grows in a bleak and barren wilderness, but he has sources of joy and of refreshing which the world knows not. The allurements of the world twine round him, and he is surrounded by trials and temptations, but they do not impede his growth. He towers above all, pointing heavenward. Linnæus called the palms the princes of the vegetable kingdom. So the believer, as a prince, has power with God and prevails through his living head.—(Gen. xxxii. 28.) The palm, which used to be a frequent tree in Palestine, is now said to be rare. Like the righteous, it has been rooted out, and is, as it were, a small remnant in a land where once it flourished in beauty and vigour. The clusters of fruit which palms produce when old, and the fatty oils which they supply, may be referred to in the statement that the righteous "shall still bring forth fruit in old age; they shall be fat and flourishing."—(Ps. xcii. 14.)

80. Another conspicuous permanent stem is that which occurs in ferns, especially in the tree-ferns of New Zealand, as well as of warm countries (fig. 25, p. 40.) In these plants the stem is uniform in its diameter, hollow, and marked on the outside by the scars of the leaves (fig. 80, *C.*) The stem increases by additions to the summit, and hence the plants are called summit-growers or *acrogens*. The

stem is, in fact, formed of the bases of the leaves, which carry up the growing point with them, and the elegant clusters of feathery leaves hang from the top. On making a transverse section of such a stem, the appearances seen are represented in fig. 81,

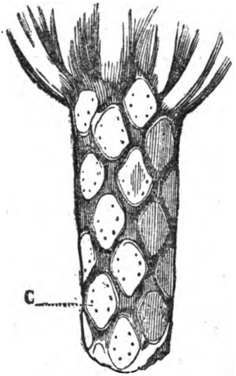


Fig. 80.

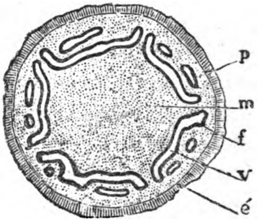


Fig. 81.

where *e* is the outer portion, marked by the scars of fallen leaves, *f v*, bundles of vessels of an irregular form, dark outside, pale in the centre, *p*, outer layer of cellular tissue, *m*, central cells, which are usually absorbed so as to leave a cavity. In the common brake or brackens of our

Fig. 80.—Stem of a tree-fern. It is acrogenous or increases at the top. The stem is uniform in diameter, marked by scars of fallen leaves, *C*.

Fig. 81.—Transverse section of the stem of a tree-fern, showing the cellular portions *p m*, the irregular bundles of vessels *f v*, and the outer portions *e*.

pasture, the lower part of the stem, when cut, exhibits bundles of vessels which have the form of an oak or of a double spread-eagle. Ferns characterize mild and moist climates, and they give a peculiar feature to the landscape of New Zealand. At former epochs of the earth's history, they appear to have constituted a large part of its vegetation.

81. We have thus seen the structure of the three marked forms of permanent woody stems, which are met with in the vegetable world:—1. Exogenous or outside-growers, consisting of pith, concentric circles of wood, which increase by additions on the outside, separable bark, and rays connecting pith and bark; exemplified in the forest trees of Britain. 2. Endogenous or inside-growers, consisting of a mass of cellular tissue with bundles of woody and other vessels scattered irregularly through the tissue, increasing by additions inside; exemplified in palms. 3. Acrogenous or summit-growers, formed by the bases of the leaves which carry up the growing point, additions being always made to the summit, bundles of vessels irregular; exemplified in tree-ferns.

82. We have already seen (p. 70), that the plants of the globe may be divided into three great classes by the nature of their embryo, viz.:—into Dicotyledonous, having two seed lobes, monocotyledonous, having one, and acotyledonous, having none. These

divisions correspond to those founded on the structure and development of the stem. Thus dicotyledons have exogenous stems, monocotyledons have endogenous stems, and acotyledons have acrogenous stems. Here we see a natural division of the flora of the world, and we perceive part of that wonderful plan which it has pleased the Creator to adopt in the formation of the plants with which He has clothed the globe. Uniting plants by affinities, such as those now stated, is following what is called a natural system in botany. By associating plants which agree in all essential points—as, for instance, in the structure of their seeds, stems, leaves, and flowers—we follow a more useful and philosophical method, than by taking into account only one or two parts of the plant, as was done by Linnæus and the advocates of an artificial arrangement.

83. The use of the stem is to support the leaves and flowers, and to expose them to air and light. The general form of stems is fitted to secure stability, and it is said that the bole of an oak suggested to Mr Smeaton the form best suited for the construction of the Eddystone Lighthouse. The sap circulates in the vessels and cells of the stem as well as in the spaces between them. In its upward course, it passes chiefly through the internal parts, being moved onwards by the force of imbibition and by capillary attraction, as modified

by vital actions. When it has reached the leaves and has undergone certain changes, it returns towards the bark in its downward course. This course is indicated in fig. 82. The sap enters by

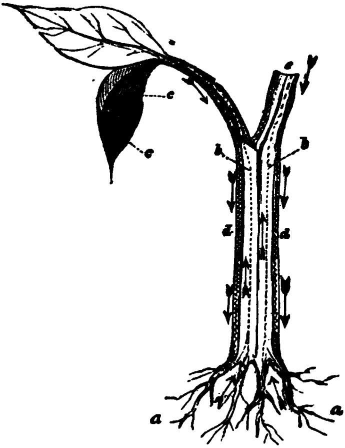


Fig. 82.

the cells of the roots *a a*, ascends through the central parts of the stem *b b*, reaches the leaves *c c*, and returns by the bark *d d*. The arrows are placed to point out this course. The force with which the sap ascends is very great. It was measured by

Fig. 82.—Figure intended to represent generally, the upward and downward course of the sap. *a a* the roots, *b b*, vessels, cells, and intercellular canals of the stem, *c c*, leaf-stalk and leaves, *d d*, bark, *e*, section of a branch. The direction of the arrows shows the course of the sap.

Hales, by means of an instrument represented in fig. 83, where *a* is the trunk of a tree such as the vine, *fged* is a bent glass tube containing mercury, which stands at the level *ef*; *b* is the extremity, of the tube which is fastened to the trunk by means of a bladder *c*, firmly tied round. The sap, when flowing freely, forced the mercury to the point *g*.

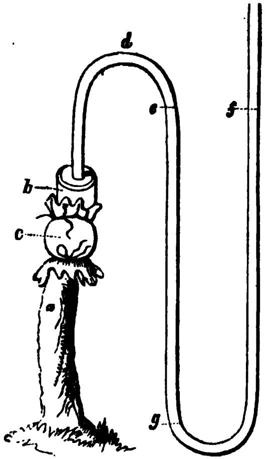


Fig. 83.

84. In the same way, the force of imbibition, or endosmose, as it is called, has been shown by the instrument represented in fig. 84. This instrument is called a measurer of imbibition or an endosmometer. It consists of a bent glass tube with a large bell-like extremity, full of syrup, covered with a bladder, which may represent a vegetable membrane, and plunged into a jar of water. The syrup is introduced by the opening at the curvature of the tube *c*, which is secured by a plug firm-

Fig. 83.—Instrument used by Hales to show the force of the sap, consisting of a bent tube *fged*, attached to the trunk of a vine *a*, by a large extremity *b*, and a bladder *c*.

ly held down. Mercury is put into the tube *a*, so as to fill the lower curvature, *d*, up to a certain point, as represented by the dark lines. Syrup occupies the space between the mercury and the bladder. After the apparatus has been in the water for some time, the mercury begins to rise in the limb *a*, by the pressure behind, caused by the rapid imbibition of water, and the force can be estimated by having a graduated scale connected with the tube. When the syrup is dense, it is found that the imbibition is very powerful, and may amount to the force of three or four atmospheres—that is, it may equal 45 or 60 pounds, or even more, on the square inch of surface. Similar phenomena

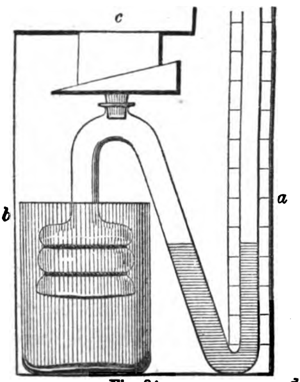


Fig. 84.

Fig. 84. Endosmometer of Dutrochet, or measurer of the force of imbibition or endosmose. It consists of a bent tube *a*, with a graduated scale attached. Its extremity *b*, large, covered at the open end, with a bladder or membrane of any kind. Syrup is poured into the large extremity through the opening *c*, which is closed firmly by a plug afterwards, and then it is put into a vessel of water. The effect on the mercury at the curve *d* shows the force.

take place in plants through the membranes covering their cells and vessels, which may be compared to the bladder in the figure. By means of this force, in part, as well as capillary attraction, the movement of the sap takes place. This, however, will not account for it entirely, and we must look to other causes besides those of a physical nature in determining the movements of fluids in living bodies. We shall find that the process of exhalation, or giving out of fluid from the leaves, materially assists these agencies; and in the case of laticiferous vessels, the conspicuous movements of the sap in them appear to be influenced by some vital powers, not yet determined. In fig. 85, is given a drawing of these vessels in the celandine, with arrows indicating the course of the fluids. The movement requires a good microscope in order that it may be seen, and also demands careful management so as to avoid all source of fallacy. The peculiar sheath which covers the leaves of the India rubber fig in its young state, is one of the best objects for showing this circulation, which ought to be looked for when the plant is growing, and in circumstances in which no injury is inflicted.

85. Various are the uses to which the woody stems of trees are applied. The heartwood of exogens is more durable than the outer or sapwood, and is less liable to attacks from dry-rot, which is caused by the growth of a peculiar kind

of mould. The outer bark often becomes very thick, and in the cork oak (fig. 19, p. 36), it supplies the important substance called cork. The inner bark is fibrous, and is used to furnish ropes

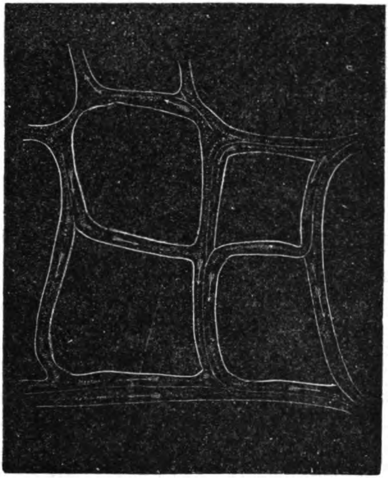


Fig. 85.

and mats. What are called Russian mats are procured from the inner bark, the *bast*, of the lime tree. The inner bark of the lace-bark tree exhibits beautiful meshes like lace. Hemp and flax

Fig. 85.—Portion of the leaf of Celandine, showing the laticiferous vessels in which movements of fluids take place, as indicated by the arrows.

are the produce of the part of the plants which corresponds to the bark. A kind of hemp in India is procured from the inner bark of a species of *Hibiscus*. Many of the nettle tribe also yield useful fibres from the bark. The grass tree of China (*Boehmeria nivea*), which yields fibres used in manufacture, belongs to this tribe. The inner bark of trees is also used in some countries for manuscripts, and hence the name of liber or book applied to it.

VI.—ON THE NATURE OF BRANCHES.

86. These are produced in the form of buds, which are connected with the centre of the woody stem. They occur especially in exogens, and they have the same structure as the stem from which they proceed. Branch-buds are arranged on the stem in a regular manner, and follow the same law of spiral symmetry as we shall see to be the case with the leaves. But, owing to various causes, it is rare to find all the buds properly developed. Many lie dormant and do not make their appearance as branches unless some injury has been done to the plant; others are altered into thorns; others, after increasing to a certain extent, die and leave knots in the stem. That thorns are, in reality, undeveloped branches, is shown by the fact that they are connected with the centre of the stem, that they bear leaves in certain circumstances, and

that under cultivation they often become true branches. Many plants are thorny in their wild state, which are not so under cultivation, owing to this transformation. Thorns, as of the Hawthorn, differ totally from prickles, such as occur in the rose. The latter are merely connected with the surface of the plant, and are considered as an altered condition of the hairs, which become hardened in their structure.

87. In the curse which God pronounced on the soil when man fell, he said, " Cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life. Thorns, also, and thistles shall it bring forth to thee."—(Gen. iii. 17, 18). May we not see, in the production of injurious thorns, an arrestment by the fiat of the Almighty in the formation of branches, and thus a blight passed on this part of creation, a standing memorial of the effects of sin on what was declared at first to be very good? The same remark may be made in regard to prickles, which are well seen in the briar and bramble, and which may be considered as an alteration in the development of hairs, a change on them which is associated with injury to man. We often find thorns, briars, and brambles alluded to in the Sacred Writings as indications of the wrath of God against a backsliding and rebellious people. In Heb. vi. 8, St Paul says, " That which beareth thorns and briars is rejected, and is nigh

unto cursing; whose end is to be burned." In proclaiming the judgments of the Lord, Isaiah says, "There shall come up briars and thorns."—(v. 6.) "All the land shall become briars and thorns."—(vii. 24.) "Thorns shall come up in her palaces, nettles and brambles in the fortresses thereof."—(xxxiv. 13.) So also Hosea says, "Thorns shall be in their tabernacles" (ix. 6), and "The thorn and the thistle shall come up on their altars."—(x. 8.)

88. Travellers in Palestine have particularly remarked the abundance of prickly and thorny plants in the land. Mr Dautrey, in his work entitled The Bible in Palestine, states, "That the plain near Tiberias is in many places a complete wilderness of thorns and thistles. They render some of the hills impassable, and entangle the foot of the traveller on spots formerly rich in culture." In many parts of Syria, cactuses form impenetrable barriers on account of their prickles. In the narrative of the Church of Scotland Deputation to Palestine, it is stated:—"Dr Keith, observing one of the adjoining hills to be very verdant and not very steep, set out for the purpose of climbing it. After a short absence, however, he returned to tell us that he had failed in his attempt. He found the surface overgrown with strong briars and thorns, through which he tried to make his way, but without success." How complete the

fulfilment of the prophecy, "They shall lament for the teats, for the pleasant fields, for the fruitful vine. Upon the land of my people shall come up thorns and briars!"—(Isa. xxxii. 12, 13.)*

89. Dr Cleghorn remarks, "That the great prevalence of prickly shrubs all over India is observed by every one; they are a continual source of annoyance to the traveller, and a fruitful cause of admission into hospitals, as every regimental surgeon can testify. The prickles and spines of these plants wound the barefooted pilgrim, especially during the hot months, when the leaves having dropped off, the thorns are left bare and exposed; on this account travelling is rendered extremely difficult in some parts, for the spines are so strong as to pierce a shoe or sandal of dressed leather; and if the weary traveller seeks to rest himself, he must beware as much of thorns as of red ants, tarantulæ, and other biting insects which infest the soil."†

90. It is remarkable to notice that when Christ became a curse for his people, the Jews mocked Him by putting on Him a crown of thorns; and thus, what was an indication of the fall of man,

* Some of these thorny plants of Palestine are *Zizyphus Spina-Christi*, *Zizyphus Paliurus*, *Tribulus terrestris*, *Ononis spinosa*. See Kitto's Biblical Cyclopædia, article Thorns and Thistles.

† For a full account of the thorny Indian plants, see Dr Cleghorn's paper on the hedge plants of India in the Annals of Natural History, second series, vol. vi. p. 233.

was used by them to insult the seed of the woman who came to bruize the head of the serpent. The removal of the curse from creation, which is now groaning and travailing in pain (Rom. viii. 22), is frequently set forth by illustrations taken from the disappearance of briars and thorns. Thus, in Isa. lv. 13, it is said, "Instead of the thorn shall come up the fir tree, and instead of the briar shall come up the myrtle tree; and it shall be to the Lord for a name, for an everlasting sign that shall not be cut off." Ezekiel says, "There shall be no more a pricking briar unto the house of Israel, nor any grieving thorn of all that are round about them that despised them; and they shall know that I am the Lord God."—(xxviii. 24.) "In that day shall the *branch* of the Lord be beautiful and glorious, and the fruit of the earth shall be excellent and comely for them that are escaped of Israel."—(Isa. iv. 2.) When He who is the Branch out of the root of Jesse (Isa. xi. 1) shall take to Himself the kingdom, there shall be nothing to hurt nor destroy in all God's holy mountain; for the earth shall be full of the knowledge of the Lord, as the waters cover the sea.—(Isa. xi. 9, and lxv. 25.) Then shall the "Spirit be poured upon us from on high, and the wilderness shall be a fruitful field, and the fruitful field be counted for a forest. Then judgment shall dwell in the wilderness, and righteousness remain in the fruitful field. And the work of righteousness

shall be peace; and the effect of righteousness, quietness and assurance for ever."—(Isa. xxxii. 15–17.)

VII.—ON THE STRUCTURE, ARRANGEMENT, AND FUNCTIONS OF LEAVES.

91. The structure of leaves exhibits a beautiful arrangement of cells and vessels, as seen in fig. 86, where the dark lines indicate the vessels or veins of the leaf, and the intermediate spaces the cellular parts of it. On making a section of a leaf from the upper to the under surface, and examining it under the microscope, we see the texture more clearly. This is delineated in fig. 87. The upper skin of the leaf is marked *E s*, the lower *E i*, and between these are the cells and vessels. The cells at the upper side *P s*, are placed close together with occasional air cavities *M*; those of the lower side *P i*, are more loose, and have numerous air spaces *L*. The bundles of vessels forming the veins are marked *F v*, while *P* shows hairs projecting from the surface,

Fig. 86.

Fig. 86.—Reticulated leaf of the white dead-nettle (*Lamium album*), showing the distribution of the veins, or what is called veination.

and *S T* an opening through the skin into the cavity below. When leaves are left for a long time to macerate in water, the cellular part is destroyed, and the veins or vascular parts are left, forming the

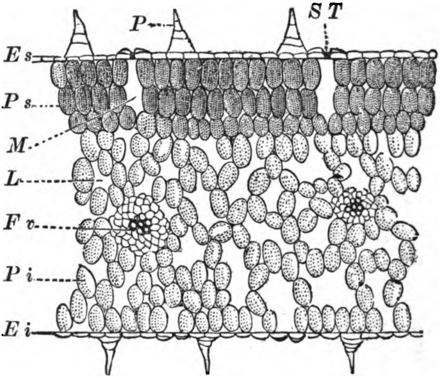


Fig 87.

skeleton. How often have we seen leaves which have lain in ditches during the winter exhibiting a beautiful net-work of veins. In India and China, skeleton leaves are made from the leaf of a kind of fig (*Ficus religiosa.*) How interesting, it has been remarked, is the anatomy of a single leaf, which, though so fragile as to tremble in every

Fig. 87.—Section of the leaf of a melon, perpendicularly to its surface; *E s*, upper epidermis or skin; *E i*, lower epidermis or skin; *P s*, cells of upper part of leaf; *P i*, cells of lower part of the leaf; *F v*, bundles of vessels; *L*, air cavities; *M*, cavity below a stomate; *S T*, a stomate; *P*, a hair.

wind, yet holds connections and living communications with the earth, the air, the clouds, and the distant sun, and through these sympathies with the universe itself!

92. As regards the distribution of veins in leaves, flowering plants may be divided into two great classes: one having reticulated leaves, or exhibiting an angular net-work of vessels, as in fig. 88,

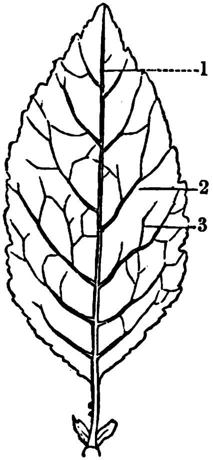


Fig. 88.

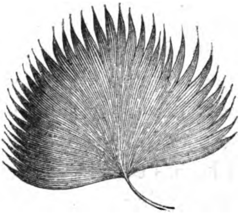


Fig. 89.

which represents the leaves of the ordinary trees

Fig. 88.—Leaf of cherry, showing distribution of veins. 1, Midrib; 2, primary veins, given off from the midrib; 3, secondary veins.

Fig. 89.—Palm leaf, showing parallel venation, the veins not being reticulated.

of this country; the other having no proper net-work, but a set of parallel or diverging veins running from the base to the extremity, as in grasses and palms (fig. 89), or from the midrib to the margin, as in Bananas (fig. 13, p. 33), and Indian-shot. The first kind of leaf occurs in dicotyledons or exogens, the second in monocotyledons or endogens. This constitutes another means of discrimination between these two great classes of plants, and is one which can be easily detected by the student of nature.

93. Sometimes the veins of leaves become hardened at their extremity, and project in the form of thorns, as seen in the holly (fig. 90), and the barberry. The same remark may be made in regard to them as has been applied to other thorns. They are produced by an arrestment in the development of the cellular part of the leaf, and a change in the structure of the veins. In the holly, we see that in certain circumstances it produces spineless leaves, in consequence of the cellular tissue filling up the spaces between the veins, even to the very edge. The poet has alluded to this in the following lines, but he has certainly given reins to his imagination in attempting to give a reason for the difference in the two kinds of holly leaves:—

> "O reader! hast thou ever stood to see
> The Holly-tree?
> The eye that contemplates it well, perceives
> Its glossy leaves,
> Ordered by an Intelligence so wise
> As might confound the Atheist's sophistries.

Fig. 90.

Fig. 90.—Holly, showing the spines of the leaves depending on non-development of the cellular tissue at the margin, and the hardening of the extremities of the veins.

"Below a circling fence its leaves are seen
Wrinkled and keen;
No grazing cattle thro' their prickly round
Can reach to wound;
But as they grow where nothing is to fear,
Smooth and unarmed the pointless leaves appear."

94. The surface of leaves presents certain pores, called stomata (fig. 91, *st;* and fig. 87, p. 116, *st*) The cells surrounding these pores are so constructed that in dry weather they collapse, and close the opening; while in moist weather they have a crescentic margin, by which they open the orifice. They are connected with the passage of air and fluids to and from the leaf. In fig. 91 they are seen scattered over the surface at regular intervals. They are easily seen by putting a very thin piece of the skin of the leaf of a hyacinth or lily under the microscope. They vary much in their form and appearance in different plants.

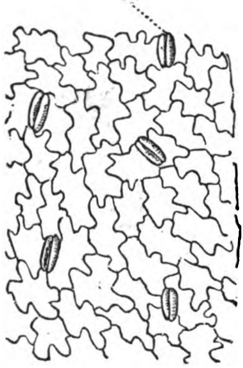


Fig. 91.

Fig. 91.—Stomata *st*, or openings in the epidermis or skin of the leaf of Balsam. There are five of these represented in the figure, placed at regular intervals. They are connected especially with the exhalation of fluids.

95. In the form and size of leaves we may perceive many interesting adaptations. Thus the large fan-shaped leaves of palms are fitted for shade and shelter in the warm countries in which they grow; while the narrow leaves of pines and firs fit them for the alpine districts in which storms and blasts prevail. In leaf-buds, also, wonderful provision is made by the Creator for the preservation of their contents. They are a sort of winter-quarters, in which the young leaves and branches are nursed. With this view, they are covered with coarse external leaves, or with a coating of gummy or resinous matter. It is only when the genial warmth of spring calls them forth that they burst their cerements, and expand their delicate structures to the air. Our native plants protrude their leaves cautiously, and thus are seldom injured much from our variable springs; but exotics transplanted from temperate climes, where spring is continuous, and there are no nipping frosts to arrest growth, are often, as it were, deceived by a few days of warmth in our northern climate, put off their winter clothing too soon, and thus suffer severely for their temerity. The time of putting forth the leaves indicates the nature of the seasons, as well as the time of the falling of the leaves. On this subject Dr Fleming has entered, in his excellent work on the curves of temperature, which has appeared as one of the series of the

"Christian Athenæum," and it is needless to dwell upon it here.

96. The function of the leaves is to expose the juices of the plants to light and air, and thus to aid in forming the woody matter of the stem, and the various secretions. Unless the leaves are freely exposed to air and light, the wood is not properly formed. Hence the reason why the wood is deficient both as regards quantity and quality in trees grown in crowded plantations. The same observations apply to all the secretions of plants. Thus potatoes grown in the shade, by which the functions of their leaves are impeded, become watery, and produce little starch in their tubers. Leaves also give off a quantity of watery fluid. This constitutes what is called exhalation. The amount of fluid exhaled varies according to the structure of the leaves and the nature of the climate. When the texture of the leaf is hard and dry, as in some Australian plants, or the skin covering the leaf is thick and dense, and has few stomata, as in the American aloe and in the oleander, the exhalation is comparatively small. In this way certain succulent plants, as cactuses, are enabled to withstand the effects of dry and hot climates without being dried up by the great loss of fluid from exhalation. The thick covering of hairs, as well as the waxy coating on some leaves, seem to be connected with the amount of exhalation.

Some very hairy plants have been known to withstand the effect of great and continued drought.

97. "Plants exhale fluid from their leaves, in the first place, for their own benefit. But various important secondary effects follow from this process. One of these is maintaining a suitable portion of humidity in the air. Not only do they attract and condense the moisture suspended in the air, and borne by the wind over the earth's surface, which, falling from their leaves, keeps the ground below moist and cool; but they can, by means of their roots, pump it up from a very considerable depth; and, raising it into the atmosphere, diffuse it over the face of the country. Trees, by the transpiration from their leaves, surround themselves with an atmosphere constantly cold and moist. They also shelter the soil from the direct action of the sun, and thus prevent evaporation of the water furnished by rains." In this way they contribute, as Humboldt states, to the copiousness of streams. When forests are destroyed, as they are every where in America by the European planters, with an imprudent precipitation, the springs are entirely dried up, or become less abundant. The inconsiderate felling of woods, or the neglect to maintain them, has changed regions noted for fertility into scenes of sterility. The droughts which so often visit the Cape de Verd Islands are attributed to the removal of their forests. A disregard of

this point may do great harm to Australia—a country where drought is already sufficiently injurious. In wooded countries, where the rains are excessive, as in Rio Janeiro, the climate has been improved by the diminution of the trees.

98. Another and most important function of leaves is to keep up the purity of the atmosphere. A poisonous gas, called carbonic acid gas, is constantly sent into the air by the breathing of man and animals, and by the various processes of combustion; and this gas is decomposed by leaves and the green parts of plants, under the influence of light. They are thus enabled to separate the carbon for their own use as food, and to give out oxygen gas, which constitutes the part of the air necessary for breathing. The carbonic acid gas exhaled from the lungs of a single individual in 24 hours contains, on an average, five to eight ounces of carbon—a substance familiar to all in the form of wood-charcoal. A full-grown man, therefore, will give off from his lungs, in the course of a year, 110 to 180 pounds of carbon in the form of carbonic acid. "If we suppose," says Professor Johnston, "each individual of Great Britain, young and old, to expire only 80 pounds of carbon in a year, the 20 millions would emit 700,000 tons; and allowing the cattle, sheep, and all other animals to give off twice as much more, the whole weight of carbon returned to the air by respiration

in this island, would be about two millions of tons." Besides this, we must take into calculation the quantity derived from the combustion of about 20 million tons of coals, in order to ascertain the amount to which the atmosphere in Britain is vitiated. All the carbon is employed in the growth of plants.

99. The leaves of plants growing vigorously are thus made subservient by the all-wise Creator to most important ends. The carbon, which in its combination with oxygen is so deleterious, is an important ingredient in plants, and is taken up by them in the form of carbonic acid. Plants of warm climates, with large evergreen leaves, and under the blaze of a tropical sun, contribute to supply the pure air to other regions where the leaves fade and the light is deficient. Liebig says: "The proper, constant, and inexhaustible sources of oxygen gas are the tropics and warm climates, where a sky seldom clouded permits the glowing rays of the sun to shine upon an immeasurably luxuriant vegetation. The temperate and cold zones, where artificial warmth must replace the deficient heat of the sun, produce, on the contrary, carbonic acid in superabundance, which is expended on the nutrition of the tropical plants." It is only during light that leaves have their decomposing power. During the night no such process goes on; and if they are kept long in darkness, leaves lose their

green colour, become pale and sickly, and deteriorate the air.

100. These functions of leaves may be used to illustrate the Christian life. The world lieth in darkness in the wicked one.—(1 John v. 19.) Satan is the prince of the power of the air (Eph. ii. 2), and he has poisoned the moral atmosphere. The people of God are the children of the light and of the day; they are not of the night or darkness.—(1 Thes. v. 5.) A new life is imparted to them, and the light of the glorious gospel has shined into their hearts.—(2 Cor. iv. 4–6.) They live in the shining of the Sun of Righteousness, who has arisen upon them with healing in his wings.—(Mal. iv. 2.) So long as they are in His light, they are green and vigorous; and they are made the means, in His hand, of purifying the spiritual air. They make their light shine before men, that others, seeing their good works, may glorify their Father who is in heaven.—(Matt. v. 16.) Their presence on the earth is made by God the reason of His sparing the inhabitants thereof. Ten righteous would have saved Sodom.—(Gen. xviii. 32.) How little do the world think of what it owes to the despised people of God! Of themselves, however, they can do nothing: it is only in the light of Christ. If left in darkness, they would pollute the atmosphere. The more fully the Sun of Righteousness shines on them, the more spiritual vigour and growth do they

display. Often He hides His face under a cloud, but still there is light; and although in such seasons their faith may languish, yet it will revive, for the clouds and mist shall pass away, and there will be, as it were, the clear shining after rain.—(2 Sam. xxiii. 4.)

101. It has been already mentioned that the green colour of leaves is due to the action of light, and that when kept long in darkness they become pale. In preparing certain delicacies for the table, the gardener blanches plants, that is to say, he makes them grow in darkness, or at least partially covered from the light. In this way the plants lose their green colour, and they do not form their proper secretions. In place of woody fibres, only delicate cells and spirals are produced, and thus the plants are rendered tender. In this way, the leaf stalks of celery and sea-kale and the shoots of asparagus are made fit for use. The heart of the cabbage is rendered white and delicate by the outer leaves screening it from light. By the same process the odours of plants are weakened or destroyed.

102. Leaves exhibit peculiar forms in consequence of being folded so as to form what are called pitchers. There are various kinds of pitcher-plants. The pitcher of an American pitcher-plant (*Sarracenia*), is represented in fig. 92, while that of an East Indian plant (*Nepenthes*), is seen in

fig. 93. In the latter, there is a distinct lid, which

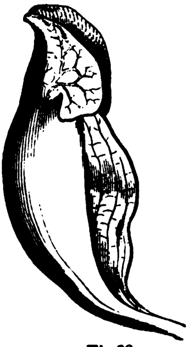


Fig 92.

Fig. 93.

is folded over the mouth of the pitcher at first, but ultimately rises, as shown in the wood-cut. The fluid in the pitcher before the lid opens contains certain saline matters in solution. One of the Indian pitcher-plants called *Dischidia Rafflesiana,* climbs to the top of the lofty trees and produces pitchers only among the upper leaves. There it is that the plant sends out little rootlets which enter the pitchers and derive nourishment from the rain and dew which are thus collected. So it is that in rising to places of eminence and distinction, we

Fig. 92.—Pitcher of *Sarracenia purpurea,* a North American marsh plant.

Fig. 93.—Pitcher of *Nepenthes distillatoria* from the Indian Archipelago. It hangs by a narrow portion from the end of the leaf, and has a distinct lid which closes the orifice at first.

ought ever to carry with us that reservoir of Truth, whence alone we can derive the precious dews of heaven, to refresh and invigorate our souls.

103. Another interesting phenomenon exhibited by the leaves of plants, is irritability. This is manifested by certain movements which they display either spontaneously or under the influence of mechanical and chemical stimuli. In the plant called Venus's Fly-trap (fig. 94), the leaf is furnished with three projecting hairs on its blade, as seen in the expanded leaf on the figure, which, when touched, immediately cause the leaf to fold upon itself, and thus enclose any insect that may have alighted on it. In the Sensitive-plant (fig. 95), the slightest touch causes the little leaflets to fold together in the way shown in the figure, and if the irritation is continued, the whole leaf falls down. These movements are in-

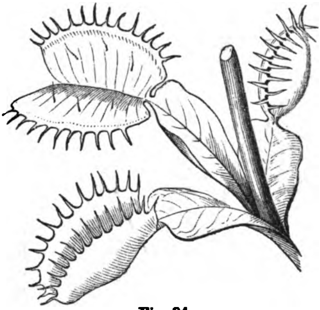


Fig. 94.

Fig. 94.—*Dionæa muscipula*, Venus's Fly-trap, a North American marsh-plant, which displays irritability of its leaves. One leaf is expanded, showing the two parts of the blade with three projecting hairs on each, which, when touched, cause the parts of the blade to fold, as shown in the other two leaves.

duced by the action of ether, chloroform, prussic acid, and many other substances. If the cause of irritation is removed, and the plant is left undisturbed, it gradually recovers its natural state. During the night, the leaflets close and the leaf is depressed. In the Moving-plant of India (*Desmodium gyrans*) as shown in fig. 96, there

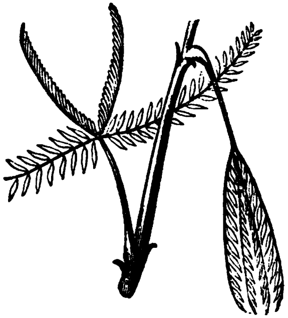


Fig. 95.

Fig. 96.

are two little leaflets which are in constant motion, jerking from one side to the other in a

Fig. 95.—*Mimosa pudica*, Sensitive-plant. The stem with two leaves. Each leaf is composed of numerous leaflets on a common stalk. In the lower leaf, the leaflets are expanded at one part and closed at the other. In the other leaf all the leaflets are closed, and the whole leaf has fallen down.

Fig. 96.—*Desmodium* or *Hedysarum gyrans*, the Moving-plant of India. The large leaf moves slowly and imperceptibly from side to side, as well as upwards and downwards. The little leaflets are constantly jerking so as to meet in the middle and then separate again.

remarkable manner both during light and darkness. The large leaf at the end of the stalk also exhibits slow movements, rising and falling, and moving from one side to the other. During darkness, the large leaf always hangs down. These remarkable movements exhibited by the leaves of plants are not dependent on nervous and muscular power, as is the case in animals, but they seem to be caused by the greater or less distension of cells connected with the base of the leaves and of the leaf-stalks.

104. The mode in which leaves are arranged on

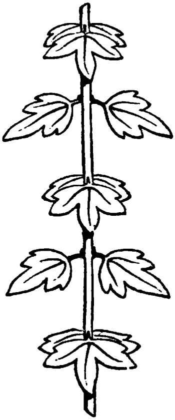


Fig. 97.

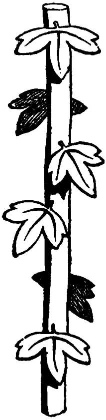


Fig. 98.

Fig. 97.—Opposite leaves on a stem, each pair is placed at right angles to that next it, thus following a law of alternation.

Fig. 98.—Alternate leaves. The sixth is placed directly above the first, and the fraction expressing the arrangement is $\frac{2}{5}$, viz. two turns round the stem and five leaves.

the stem deserves notice. They are either placed opposite to each other, as seen in fig. 97, or alternate with each other, as in figs. 98 and 99. When leaves are opposite, we frequently find that the different pairs cross each other at right angles. Thus in fig. 97, the two leaves at the base are placed to the front and back, the next two right and left, and so on. There is thus seen a law of alternation. This is more distinctly visible in the case of single leaves produced at each point of the stem. In fig. 98 there are six leaves arranged at different heights on the stem, and it will be seen that the sixth leaf is directly above

Fig. 99.

the first, and the same thing is seen in fig. 99,

Fig. 99.—Alternate leaves, arranged in the same way as in fig. 98, the number expressing the arrangement being 2-5ths.

where the leaves are numbered in succession, 1, 2, 3, 4, 5, 6. Commencing with the lowest leaf in these figures, and proceeding regularly through all the leaves until we reach the one directly above the first, we follow a spiral direction, make two complete turns round the stem, and pass through five leaves. This arrangment is expressed by the fraction $\frac{2}{5}$. In figs. 100 and 101, it is shown that in

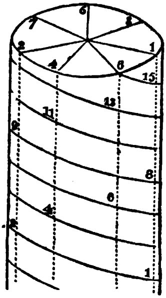


Fig. 100.

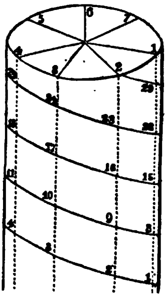


Fig. 101.

the case of alternate leaves, perpendicular lines may be drawn through the leaves placed directly over each other, and the number of these lines indicates the number of leaves in each spiral cycle, or the number of leaves between any leaf on the stem

Figs. 100 and 101.—Diagrams to illustrate the arrangement of the leaves on the stem. In each figure the cycle consists of seven leaves. In 100, the divergence between every two leaves is $\frac{3}{7}$ of a circle, or $\frac{3}{7}$ of 360°—154$\frac{2}{7}$. In 101, the divergence between every two leaves is $\frac{1}{7}$ of 360°—51$\frac{3}{7}$.

and that directly above it. In both these figures it will be seen that the number of these lines is seven, and this, therefore, is the number of leaves in each cycle. But it will also be noticed that the number of turns made round the stem in completing the cycle is different. Thus in fig. 100, commencing with leaf No. 1, we reach leaf No. 8, or that directly above 1, after making three turns round the stem, and the fraction indicating this is $\frac{3}{7}$; whereas, in fig. 101 we reach No. 8 after one turn, and the fraction, therefore, is $\frac{1}{7}$. These fractions mark the angular divergence between any two leaves of the cycle, as represented in the divided circles at the upper part of the stems. In fig. 100, between 1 and 2 the angular divergence is obviously $\frac{3}{7}$, while in fig. 101 it is $\frac{1}{7}$ of the circle. The object of this alternation in the position of leaves seem to be to allow them to be fully exposed to air and light, and to form wood equally all round.

105. The parts of the plants which we have now considered, the Root, Stem, and Leaves, constitute what are called the organs of nutrition or nourishment. Fluid matters are taken up by the cells of the roots from the soil, they are conveyed to the leaves, and there, under the influence of air and light, they are fitted for the purposes of plant life, and for the production of various secretions, such

as starch, gum, sugar, woody matter, gluten, oils, resins, &c. The nature of the soil has a material influence on the nourishment of the plant, and the process of manuring is conducted with the view of supplying certain substances which the plant requires for its vigorous growth, and which it cannot get from the particular soil in which it is placed. Some plants require ingredients which others do not need, and it is upon this principle that a certain rotation or change of crop is adopted.

VIII.—ON THE FLOWER AND ITS VARIOUS PARTS.

106. The flower and its parts are denominated the organs of reproduction, inasmuch as they are concerned in the production of seed which contains the embryo or young plant. The parts of a flower are usually arranged in four series, or as they are called whorls:—1. The calyx. 2. The corolla. 3. The stamens. 4. The pistil. These parts are seen in figs. 102 and 103, in which *S* is the calyx, *P* the corolla, *E* the stamens, and *STI* the pistil. In fig. 102 the different series of the flower are complete, in fig. 103 the calyx and corolla are removed. These are all considered as formed by leaves altered so as to suit the particular functions which each part performs. They sometimes appear in the form of true leaves without any marked modification. The inner two of the

series are essentially connected with the production of seed, and are called essential organs (fig. 103.) The outer two are protective and nutritive organs,

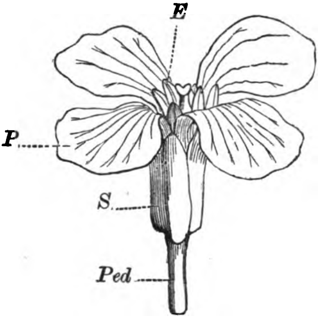


Fig. 102.

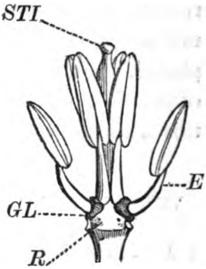


Fig. 103.

and are called floral envelopes. When flowers become double, the stamens and pistil are more or less completely changed into parts resembling the outer series, and when the alteration is complete, no seed is produced. In the eyes of a florist, the more perfect the change, the finer is the flower; while the botanist looks upon such as monstrous, and imperfect as regards the function of reproduction.

107. The parts of each series or whorl are ar-

Fig. 102.—Flower of common Wallflower. *Ped* the flower-stalk, *S* the calyx, *P* the corolla, *E* stamens.

Fig. 103.—Same flower with calyx and corolla removed. *E* stamen, *STI* pistil, its upper part called the stigma, *R* the receptacle to which the parts of the flower are attached, *GL* a small gland at the base of the stamen.

ranged like leaves on the principle of alternation, and there is a remarkable symmetry as regards the number of the parts. Throughout the vegetable kingdom, the numbers which generally prevail are 5 and 3, or multiples of them. Thus if a flower has 5 parts of the calyx, it has usually 5 of the corolla alternating with them, 5, 10, 20, &c. stamens, and 5 or some multiple of 5 in the parts of the pistil. So also with those flowers which have 3 parts in the calyx. In fig. 104 a diagram is given showing the alternation of the 5 parts of each whorl of the flower. It is also found that the numbers 2 and 4 are met with, although by no means so frequently as those already mentioned. It is worthy of notice that flowers exhibiting 5 or 4, or multiples of these numbers in their whorls, usually belong to plants having two seed-lobes or cotyledons, and which, when they form permanent woody stems, exhibit distinct zones or circles, and have separable bark; while flowers, having 3, or a multiple of 3, in their whorls, present only one seed-lobe, and when they form permanent woody stems exhibit no distinct zones nor circles, and have no separ-

Fig. 104.

Fig. 104.—Diagram to show the arrangement of the parts of the flower. There are four whorls, each consisting of five parts, which alternate with those next them.

able bark. The numbers 2 and 4, or multiples of them, are seen also in the parts of fructification of flowerless plants which have no seed-lobes, such as ferns, mosses, sea-weeds, &c. The processes which project from the urn-like cases of mosses, are arranged in the series, 4, 8, 12, 16, 32, 64, &c. The parts of fructification of scale-mosses (Jungermanniæ) are in fours, as also the germs of some sea-weeds. Thus the numbers 5 and 4 and their multiples prevail among dicotyledonous and exogenous plants; the number 3 and its multiples occur among monocotyledonous or endogenous plants; while 2 and 4, and multiples of them, are met with among acotyledonous or acrogenous plants.

108. The arrangement of the flowers on the stem varies. Flower buds are produced either at the extremity of the main stalk, as in the little gentianella; or they are produced at the points where the leaves join the stems, as in the periwinkle and scarlet pimpernel (fig. 105). In the former case, a single flower terminates the floral axis, and any other flowers which may be afterwards developed are always further from the centre. In the latter case, the axis goes on lengthening and producing flowers as it grows; these flowers arising from leaves called *floral*, such as represented in fig. 105. These floral leaves are sometimes very small and coloured, as in the hyacinth. Occasionally, in

place of flower-buds, stalks bearing hairs are produced, as in *Rhus Cotinus* (fig. 106), which is, on that account, called the wig-tree, or the *arbre à perruque* of the French. In this case it is seen that the production of hairs indicates a degeneration of parts, or an abortive state of them.

Fig. 105.

109. The flowering of plants takes place at different periods of the year, and thus a calendar of the seasons may be constructed. By observing the exact time when plants in the same garden flower in different years, an indication will be given of the nature of the season. The mezereon and snow-drop, hepatica and winter aconite, put forth their flow-

Fig. 105.—Flowering stem of *Anagallis arvensis*, the Scarlet Pimpernel or Poor-man's Weather-glass. The floral stem or axis goes on lengthening and producing flowers at the points where the leaves (called floral) join the axis or stem. The lowest flower expands first, and the others in succession upwards.

ers in February in this country, the primrose and crocus in March, the cowslip and daffodil in April, the great mass of plants in May and June, many in July,

Fig. 106.

August, and September, the meadow-saffron and strawberry-tree in October and November, and the Christmas rose in December. Besides annual periods, some flowers exhibit diurnal periods of expansion and closing. On this principle Linnæus constructed what he called a floral clock, in which each hour was marked by the opening of some flower. The following is a specimen of such a horological calendar:—

110. *Linnæus's Floral Clock*:—

Yellow Goatsbeard, . .	3—5 A.M.
Smooth Hawksbeard, . .	4—5 „
Wild Succory, . . .	5 „
Dandelion, . . .	5—6 „
Spotted Cat's-ear, . .	6 „
Sow Thistle, . . .	6—7 „
Water Lilies, . . .	7 „

Fig. 106.—*Rhus Cotinus*, or the Wig-tree, so called on account of its flowering stalks bearing hairs in place of flowers. In the figure a solitary flower is produced; all the rest are abortive.

Small Cape Marygold, .	7	A.M.
Scarlet Pimpernel, . .	8	"
Field Marygold, . .	9	"
Ice Plant, ...	9—10	"
Sandworts, . . .	9—10	"
Knotted Figwort, . .	10—11	"
Common Star of Bethlehem (Dove's-dung of Scripture),	11	"
Many Figworts, . .	12	"
Afternoon Squill, . .	2	P.M.
Marvel of Peru, . .	5	"
Sad Pelargonium, . .	6	"
Night-flowering Catchfly, .	8—9	"
Night-flowering Cereus, .	10	"

111. Richter, in his remarks on Linnæus' floral clock, contrasts it with the periodical occupation of man at different hours of the day. "I believe," he says, "the flower-clock of Linnæus, in Upsal (*Horologium Floræ*), whose wheels are the sun and earth, and whose index-figures are flowers, of which one always awakens and opens later than another, was what secrectly suggested my conception of the human-clock. I formerly occupied two chambers in Scheeraw, in the middle of the market-place: from the front room I overlooked the whole market-place and the royal buildings, and from the back one the botanical garden. Whoever now dwells in these two rooms possesses an excellent harmony, arranged to his hand, between the flower-clock in the garden and the human-clock in the market-

place. At three o'clock in the morning the yellow meadow goatsbeard opens; and brides awake, and the stable-boy begins to rattle and feed the horses beneath the lodger. At four o'clock the little hawkweed awakes, choristers going to the Cathedral who are clocks with chimes, and the bakers. At five, kitchen-maids, dairy-maids, and butter-cups awake. At six, the sow-thistle and cocks. At seven o'clock, many of the ladies'-maids are awake in the palace, the chiccory in my botanical garden, and some tradesmen. At eight o'clock, all the colleges awake, and the little yellow mouse-ear. At nine o'clock, the female nobility already begin to stir; the marygold; and even many young ladies, who have come from the country on a visit, begin to look out of their windows. Between ten and eleven o'clock, the Court ladies and the whole staff of lords of the bed-chamber, the green colewort and the alpine dandelion, and the reader of the princess, rouse themselves out of their morning sleep; and the whole palace, considering that the morning sun gleams so brightly to-day from the lofty sky through the coloured silk curtains, curtails a little of its slumber. At twelve o'clock the prince, at one his wife and the carnation have their eyes open in their flower-vase. What awakes late in the afternoon at four o'clock is only the red hawk-weed, and the night-watchman as cuckoo-clock, and these two only tell the time as evening-clocks and moon-

clocks. From the hot eyes of the unfortunate man who, like the jalap-plant (*Mirabilis Jalapa*), first opens them at five o'clock, we will turn our own in pity aside. It is a rich man who has taken the jalap, and who only exchanges the fever-fancies of being griped with hot pincers for waking gripes. I could never know when it was two o'clock, because at that time, together with a thousand other stout gentlemen, and with the yellow mouse-ear, I always fell asleep; but at three o'clock in the afternoon, and at three in the morning, I awoke as regularly as though I was a repeater. Thus we mortals may be a flower-clock for higher beings, when our flower-leaves close upon our last bed; or sand-clocks, when the sand of our life is so run down that it is renewed in the other world; or picture-clocks, because, when our death-bell here below strikes and rings, our image steps forth from its case into the next world. On each event of the kind, when seventy years of human life have passed away, they may perhaps say, 'What! another hour already gone! how the time flies!'"

112. The closing of flowers also follows a periodical law. Most flowers close during darkness. Some close even in daylight. Thus the salsafy shuts up its heads of flowers about midday, and the chiccory about four in the afternoon. Many flowers are affected by the nature of the day as

regards moisture, dryness, cloudiness, or clearness. In cloudy and rainy weather, the flowers of the scarlet pimpernel, called poor-man's weather-glass, remain closed. So also do the heads of flowers of the daisy, dandelion, and other composite plants. By this means the essential organs of the flower are protected from injury. The direction of the flowers of some plants seems to be influenced by the sun's rays; and the name girasole, or sun-flower, was given from an impression that the heads of flowers inclined towards the part of the heavens where the sun was shining. This does not, however, appear to be the case with the sun-flower as grown in this country.

113. The diurnal periods in flowering are alluded to by the poet in the following lines :—

"In every copse and sheltered dell,
Unveiled to the observant eye,
Are faithful monitors who tell
How pass the hours and seasons by.

The green-robed children of the spring
Will mark the periods as they pass,
Mingle with leaves Time's feathered wing,
And bind with flowers his silent glass.

See Hieracium's various tribes
Of plumy fruit and radiant flowers
The course of time their blooms describe,
And wake and sleep appointed hours.

Broad o'er its imbricated cup
The Goatsbeard spreads its purple rays,
But shuts its cautious florets up,
Retiring from the noontide blaze.

On upland shores the shepherd marks
  The hour when, as the dial true,
Cichorium to the towering lark
  Lifts her soft eyes, serenely blue.

Thus, in each flower and simple bell
  That in our path betrodden lie,
Are sweet remembrancers, who tell
  How fast the winged moments fly!"

114. *The Calyx.* This is the outer covering or envelope of the flower. It is usually of a greenish hue like leaves. Sometimes, however, it is variously coloured, as in the fuchsia and Indian cress. It consists of a certain number of parts called sepals, which are either distinct from each other, as in the common buttercup and wallflower (fig. 102, p. 136), or are united together more or less completely, as in the harebell, gentianella, and dead-nettle. The calyx in the case of the gooseberry, currant (fig. 162, p. 127), pear, apple, pomegranate, and many other plants, forms a covering of the fruit, and remains attached to it when ripe. In some plants the calyx is inconspicuous, and is reduced to a mere rim or slight projection, as in hemlock and in certain Rhododendrons. In the case of such plants as the thistle, dandelion, artichoke, and others which belong to the large division called Composites, which have numerous small flowers on a common head, the calyx is united to the fruit, and appears at the upper part of it in the form of hairs or pappus (fig. 107). This is a degeneration of the calyx, which is made

subservient to the scattering of the seed, and in the case of thistles is the means of diffusing extensively these noxious weeds.

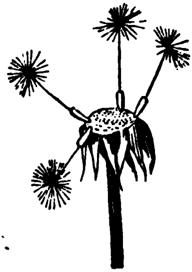


Fig. 107.

115. The order of Composites, to which the thistle belongs, is the largest and most generally diffused of all known tribes of plants. There are now as many species belonging to the order, as there were known plants in the whole world in the time of Linnæus, and almost all have the hairy calyx. Thistles themselves are generally distributed. Many species have been noticed by travellers in Syria and Palestine. Hasselquist, during a short visit to Judea, observed from eight to ten different species on the road from Jerusalem to Rama, and one on Mount Tabor. Thistles, and plants allied to them, now cover spots where formerly culture extended.* Thus the prediction of Hosea is fulfilled, "The thorn and the thistle shall come up on their altars." The injury which thistles, and plants

Fig. 107.—Receptacle or part of the dandelion on which the flowers are placed. It is represented in the dry state when the plant is in fruit, and the leaves surrounding the head of flowers are turned back so as to allow the fruit to be easily scattered by the wind. The fruit is seen with the calyx attached, and appearing above in the form of hairs or pappus.

* Among the thistle-like plants of Palestine is the *Cynara Scolymus*, the artichoke.

like them, cause to fields is very great, owing to the mode in which the fruit is scattered by the winds, and this altered hairy calyx is the means employed for doing so. May we not see in this the curse of thistles?—(Gen. iii. 18). The calyx is not developed as in other plants, but is abortive, blighted as it were and changed into hairs, which, as already shown (fig. 106, p. 140), indicate degeneration. Thus thistles add to the sweat and toil of man in the cultivation of the soil. It was the soil which was cursed by God (Gen. iii. 17), and to it we must trace the state of the vegetation. What it is in the soil which gives rise to all the degeneration in vegetable productions, and the arrestment in development, we know not. To keep up its fertility, man requires to labour constantly. The whole system of agriculture shows that materials require to be supplied, and that no soil will continue to produce good crops fit for food without the addition of manure. It may be that the sources whence fertility arises, whence the ammonia and other substances essential for plant growth are derived, may have been so closed up and so changed as to be no longer available for the purposes of man. Even in the very deteriorations and degenerations of creation we see beauty; what then must it have been when God pronounced it good? In the present earth, there are abundant indications of the curse; but we are enabled to look forward to

its removal, when there shall be a new earth as well as a new heaven, wherein dwelleth righteousness (Isa. lxv. 17, lxvi. 22; Rev. xxi. 1), when all will be complete and perfect, when the earth shall yield her increase, and God, even our own God, shall give us his blessing.—(Ps. lxvii. 6.) Believers shall then be as trees of righteousness, the planting of the Lord that He may be glorified.—(Isa. lxi. 3.)

116. *The Corolla.* This is, generally speaking, the showy part of the plant in which the gay colours of the flowers reside. It is sometimes wanting, as in nettles, willows, and catkin-bearing trees. When present, it consists of a number of leaves called petals, which are either distinct from each other, as in the butter-cup, wallflower (fig. 102, p. 136), cinquefoil, and rose, or united together in various ways, as in the gentian, foxglove, frogs-mouth, and dead-nettle. The petals are composed of a congeries of minute cells, each containing colouring matter and delicate spirals interspersed, all being covered by a thin epidermal coat, or skin. The coloured cells are distinct from one another, and thus a dark colour may be at one part and a light colour at another. How exquisitely are the colours of flowers diversified, and with what a masterly skill are their varied hues arranged! Whether blended or separated, as Thornton remarks, they are evidently under the control of a taste which never falls short of the perfection of elegance. The

Creator has added to them the charms of an endless novelty, to please the eye and contribute to the enjoyment of man. When with microscopic eye we examine the flower of the lily of the field, and observe the beautiful structure in which the colours are developed, and

"See how nature paints her colours,"

how truly may we exclaim, "Solomon in all his glory was not arrayed like one of these."—(Matt. vi. 29; Luke xii. 27). The tints of his kingly robes might have been as bright and varied; but where were the cells and the delicate tissues of the flower?

117. The colours of flowers are arranged in two marked series, the yellow and the blue. A plant belonging to the yellow series may exhibit all the tints of white, yellow, and red, but it does not appear to have the power of becoming blue. So also with a plant of the blue series. It too may exhibit varying tints of white and red and blue, but generally refuses to become yellow. The tulip, the dahlia, and the rose, belong to the yellow series; and while, by cultivation, they exhibit innumerable changes, yet they have not been made blue. The common harebell belongs to the blue series, and is not seen to assume the yellow. Such appears to be the general law, although there are no doubt some apparent exceptions, especially in cases (such as the pansy) where blue and yellow

occur in the petals of the same flower. But it still remains to be proved that a petal truly yellow can be changed by the art of the gardener into blue.

118. The fragrance and odours of flowers reside generally in the petals. These are owing to volatile matters which are not easily detected, the subtile particles of which are diffused through the air in a way which eludes the researches of man. Some colours are associated frequently with certain kinds of odours. Thus dark brown flowers, such as those of stapelias (fig. 108), have usually very fetid and disagreeable odours. Hence they are called carrion flowers, and are noted for attracting flies, which probably serve an important purpose, as will be afterwards shown, in the production of the seed. Sunshine has in general a marked effect in developing the odours of flowers. Hence in those climates where the sun displays all its brightness, the air is perfumed with fragrant odours. In many cases, alternate showers and sunshine bring out particular odours; and in some instances the perfumes are intermittent, and are only given out

Fig. 108.

Fig. 108.—Flower of stapelia, having a very fetid odour, and hence called carrion flower.

during the night. The plants called *tristes* or *sad* by Linnæus, including the night-smelling stock and pelargonium, are of this nature, and so are several species of night-flowering cereus.*

119. *The Stamens.* These form the third series of parts in the flower. In fig. 109 they are numerous, and surround the central pistil, which is longer than the stamens. Like the other parts of the flower, they are considered as a modification

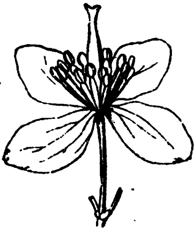


Fig. 109.

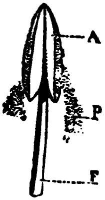


Fig. 110.

of leaves. In double flowers, they are converted into petals. They consist usually of two parts, a stalk or filament (fig. 110, *F*) supporting two small cellular bags at the top of it (fig. 110, *A*), which are called the anther lobes. The anther contains a powder (fig. 110, *P*), often of a yellow colour, called pollen, which is essential to the production

Fig. 109.—Flower of celandine. The calyx has fallen off, the four petals are seen, numerous stamens and one pistil in the centre.

Fig. 110.—A stamen consisting of filament *F*, anther *A*, and pollen *P*, discharged from slits in the anther lobes.

* See Dr Fleming's work on the Curve of Temperature, p. 53.

of perfect seed in flowering plants. At a certain period of growth, this powder is discharged from the anther, which opens by means of slits (fig. 110), or of hinges, as in the barberry and laurel, or holes, as in the heath, rhododendron, and potato, to allow its escape. The anther has two coverings, the inner of which often contains elastic spirals, which seem to assist in the opening of the lobes. The pollen, or the dust of flowers, when examined by the microscope, presents multiplied forms. It must be applied to the pistil or central part of the flower, in order that the seed may be perfected.

120. Many beautiful arrangements are made for insuring the proper application of the pollen to the upper part of the pistil. The agency of winds, of elasticity, of irritability, and of insects, is called into operation in different cases. In the common nettle, and in the pellitory of the wall (fig. 111), the stamens have elastic filaments, which are at first bent down, so as to be obscured by the calyx; but when the pollen is ripe, the filaments jerk out, as seen in fig. 112, and thus scatter the powder on the pistils, which occupy separate flowers. In the common barberry, the lower part of the filament is very irritable; and whenever it is touched, the stamen moves forward to the pistil. In the stylewort (*Stylidium*), as seen in fig. 113, the stamens and pistil are united in a common column which projects from the flower; this column is very irrita-

Fig. 111.

Fig. 111.—Pellitory of the wall (*Parietaria officinalis*), found on the walls of old castles, &c. It belongs to the nettle tribe, and has peculiar elastic stamens.

ble at the angle where it leaves the flower, and when touched, it passes with a sudden jerk from

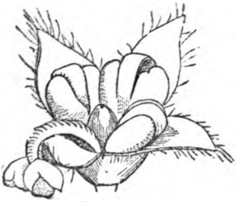


Fig. 112.

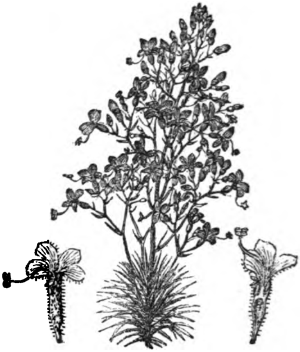


Fig. 113.

one side to the other, and thus scatters the pollen. In the hazel, where the pollen is in one set of flowers (fig. 114, ♂) and the pistil in another (fig. 114, ♀), the leaves might interfere with the application of the pollen, and therefore they are not produced until it has been scattered. In the case of firs, which have their flowers arranged as in the hazel, stamens at one place and fruit-bearing cones (fig. 133, p. 164) at another, the evergreen leaves are

Fig. 112.—Flower of pellitory magnified, showing the elastic filament of one of the four stamens, curving outwards, and scattering the pollen on the pistil-bearing flowers.

Fig. 113.—Stylewort of Australia (*Stylidium*), with two of the flowers separated, showing the irritable column composed of stamens and pistil united. This column, when the pollen is ripe, jerks from one side of the flower to another, and thus scatters the powder.

very narrow, and the quantity of pollen produced is very great, so as to ensure its reaching the young cones. In America the pollen from pine forests

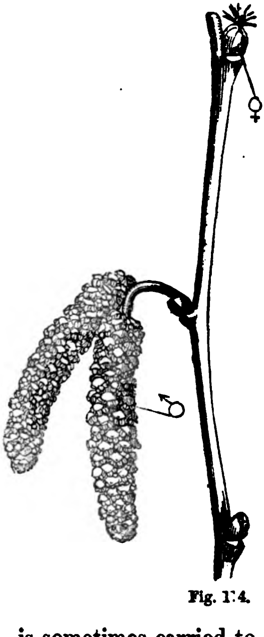


Fig. 114.

Fig. 115.

is sometimes carried to a great distance by winds, and falls in showers like sulphur. In the month

Fig. 114.—Hazel (*Corylus Avellana*), showing two kinds of flowers which are produced before the leaves. ♂ the catkins bearing stamens. ♀ the pistil-bearing flowers which produce nuts.

Fig. 115.—Willow, with a catkin or cluster of stamen-bearing flowers,

of May, in this country, a visit to a forest of firs will show the large quantity of yellow powder which falls from the trees when shaken. In the case of cucumbers in a glass frame, where the wind cannot reach the flowers, the gardener takes the pollen from the one kind of flower and applies to the other, in order that he may get fruit. In willows, the stamen-bearing and pistil-bearing flowers are on separate trees. In fig. 115 is seen a collection or catkin of flowers with stamens only, in fig. 116, another collection with pistils only.

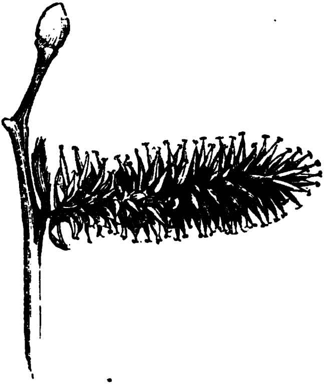


Fig. 116.

The two kinds of trees grow near each other, and the wind wafts the powder from the one to the other. In *Vallisneria spiralis* (fig. 44, p. 57), an aquatic plant, which grows in the mud of ditches in the south of Europe, the stamen-bearing plant at a certain period is detached from the mud and rises to the surface of the water, where it floats

Fig. 116.—Willow, with a cluster of pistil-bearing flowers.

and ripens its pollen. Soon after this, the pistil-bearing plant, which still remains growing in the mud, sends up a long spiral stalk, as seen in the figure, which bears the flower to the surface, where it expands. The pollen is then wafted on it by the wind, and the seed is perfected, and finally deposited in the mud.

121. Insects are often, in the arrangements of Providence, made the means of securing the production of seed. How often do we see the bees collecting the yellow powder of plants, and, while providing for the food of their young, aiding in dispersing the pollen. The honey-like matter secreted by flowers renders them attractive to insects. It is produced by an alteration in the starch, which occupies cells at the bottom of the flowers. In the common crown imperial of the gardens, there is a distinct depression at the base of each petal, in which the honey or nectar is secreted. In common buttercups, a small scale at the bottom of each of the yellow petals points out the seat of the sugar-like matter. The peculiar insect-like form of the flowers of orchids (fig. 117), such as the bee orchis, the fly orchis, the spider orchis, the butterfly oncidium, seem to be connected with the attraction of insects to the flowers, in order to apply the pollen, which in these plants is singular, both as regards its situation and nature. In the birthwort (*Aristolochia*), the flower consists of a

long tube (fig. 118) in a chamber, at the bottom of

Fig. 117.

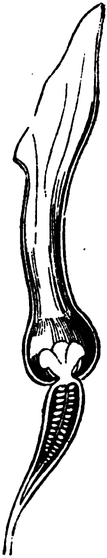


Fig. 118.

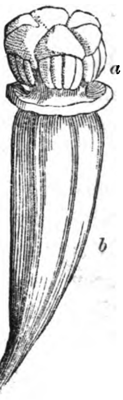


Fig. 119.

which the stamens and pistil are placed, complete-

Fig. 117.—Orchid showing the peculiar insect-like flowers which it produces. The leaves are spotted and the roots are tubercular, containing much starchy matter.

Fig. 118.—Flower of Birthwort (*Aristolochia Clematitis*) laid open, showing the long tube and the expanding upper part of the flower. The seed vessel containing seed is below the flower. The tube contains inverted hairs which are not represented in the drawing. An insect entering the flower easily passes the hairs, but in attempting to come out it is stopped.

Fig. 119.—The stamens and pistil *a*, the former placed below the part of the latter called the stigma; *b* the fruit or seed-vessel.

ly shut out from the agency of winds. The position of the stamens and pistil is seen in fig. 119, where the floral envelope is removed. This plant is frequented, in its native country, by an insect which enters the tube easily and gets into the little chamber. On attempting to get out, it is prevented by a series of hairs in the tube which all point downwards. It therefore moves about in the little cavity, and thus distributes the pollen on the pistil, soon after which the flower withers and the insect escapes. Such are a few of the provisions made by the Creator to secure the production of seed in the various tribes of plants with which the earth is clothed, and thus the "herb bearing seed" is found in all quarters of the globe.

122. *The Pistil.* This is the central part of the flower, and is composed of one or more folded leaves or *carpels.* It may consist of a single carpel, as in the pea, or of several, either distinct from each other, as in the pæony, or combined, as in the tulip. In the double-flowering cherry, in which the stamens are changed into petals, the pistil appears in the form of a flat leaf, as represented in fig. 120, or of a folded leaf, as in fig. 121. The plant does not

Fig. 120.

Fig. 121.

Figs. 120 and 121.—The pistil of the double-flowering cherry, composed of a leaf (*carpel*) either flat, as in 120, or folded, as in 121.

produce fruit on account of the change which has taken place in the stamens and pistil. The parts of the pistil are seen in fig. 122. The rounded top is the stigma, the stalk below is the style, and the lower swollen portion is the ovary, containing the cells which become seeds. These parts are better seen in fig. 123, which represents the pistil of the apricot tree laid open longitudinally, *ST* being the stigma, *TC* the style, with a canal through it, *EP*, *ME*, and *END* the three coverings of the ovary, and *OV* the young seed.

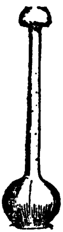


Fig. 122.

123. The grains of pollen, when discharged from the anther, are applied to the stigma (fig. 123, *ST*), and after lying on it for a certain length of time, they send out tube-like prolongations, as seen in fig. 124, where two pollen grains are seen lying on the top of the stigma, which is split open, along with part of the style, to show the pollen tubes. In fig. 125 there is a magnified representation of a

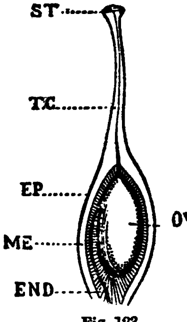


Fig. 123.

Fig. 122.—Pistil of primrose (*Primula*), showing the ovary below, the stigma at the top, and the style between them.

Fig. 123.—Pistil of apricot tree cut vertically. *EP*, outer coat of ovary, *ME* middle coat, *END* inner coat, which becomes the stone, *OV* young seed or kernel, *TC* style and its canal, *ST* stigma.

pollen grain giving out three tubes, one of which is considerably elongated. These tubes reach the rudiments of the young seed in the ovary, and by this means the embryo plant is formed. After this process has taken place, the pistil undergoes marked changes, by which it becomes the fruit containing the seed in the interior of which is the young germ.

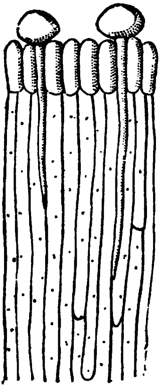


Fig. 124.

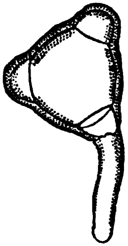


Fig. 125.

IX.—ON THE FRUIT AND SEED.

124. The term fruit, in botanical language, is applied to the mature and perfect pistil, whether dry or succulent. When we examine fruits, however, we shall find that they are formed in various ways. Some, as the pea, bean, and vetch (fig. 126), consist solely of the pistil, very slightly altered; others, as the grape, peach, and plum, consist of the pistil,

Fig. 124.—Style and stigma laid open. Two grains of pollen on the top of the stigma protruding tubes which descend through the stigma and style.

Fig. 125.—Pollen grain much magnified, showing three points where tubes come out. One of the tubes is considerably elongated.

changed so as to assume a succulent character, either entirely, as in the grape, or partially, as in stone-fruit; others, as the gooseberry, currant (fig. 127), apple, pear, pomegranate, are formed not only by the pistil, but also by the calyx, a portion of which is seen at the top of these fruits in the form of brownish scales. The hazel-fruit (fig. 128) consists of the pistil transformed into the nut, with a covering of leaves, called the husk, outside; so also the fruit of the oak, or the acorn, which has a cuplike covering (fig. 129.) In the strawberry (fig. 130), the succulent part, which is eaten, consists of the enlarged growing point, bearing on its surface numerous small carpels or fruits, which are often called seeds. The

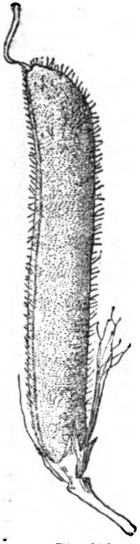


Fig. 126.

Fig. 127.

Fig. 126.—Pod of Vetch, composed of the pistil with style and stigma at the summit. The fruit in this case is composed of a single carpel containing numerous seeds.

Fig. 127.—Fruit of Currant, composed partly of the pistil and partly of the calyx; the withered remains of part of the calyx are seen at the summit of each currant.

mulberry (fig. 131), as well as the pine-apple (fig.

Fig. 128.

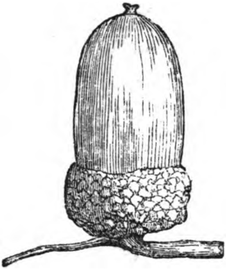


Fig. 129.

132), the bread-fruit (fig. 23, p. 38), cones (fig.

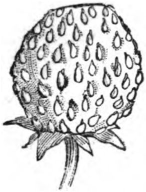


Fig. 130.

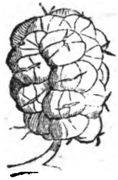


Fig. 131.

Fig. 128.—The fruit of the Hazel, consisting of the nut, with the husk outside. The husk is composed of floral leaves.

Fig. 129.—Fruit of the Oak, or Acorn, with its cup or outer covering of altered leaves.

Fig. 130.—Strawberry-fruit, consisting of a succulent receptacle, on which are scattered numerous fruits or carpels, resembling seeds.

Fig. 131.—Fruit of Mulberry, composed of the pistils of several flowers united into one mass.

133), and the fig (fig. 134), are made up of a congeries of pistils, formed by separate flowers, and all combined into one mass. In the first four, the flowers are on the outside of a common

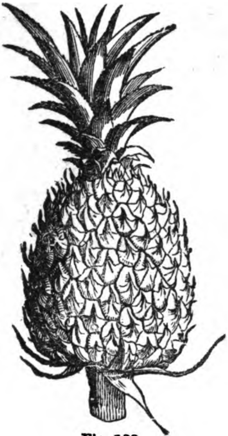


Fig. 132.

Fig. 133.

receptacle or axis; while in the fig, the succulent receptacle is curved upwards and inwards, so as to be hollow, and thus bears the flowers inside, as seen in fig. 134. In the fig, what are

Fig. 132.—Pine-apple, a fruit consisting of several succulent fruits formed by different flowers, and all united into one. The cells outside are modified leaves, while the crown is a series of leaves unaltered.

Fig. 133.—Cone of Fir, a fruit consisting of scales or hardened leaves, each representing a separate flower. The fruit is made of numerous flowers united.

called seeds are in reality fruits, like those on the top of the strawberry, but produced by numerous flowers in place of one.

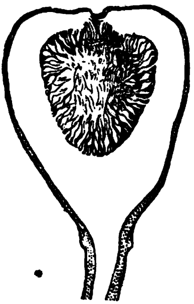


Fig. 134.

125. In common language, we apply the name fruit chiefly to that which is succulent and eatable. Various means are adopted by gardeners to render edible fruits more fit for the desert. All the varieties of apple, for instance, are produced from the wild crab by the art of horticulture. The mode in which these have been produced is by the process of grafting, or by taking a slip from the sour crab and making it adhere to the stem of another tree growing in the soil. By high cultivation and constant grafting, man has been enabled to produce fruit fitted to gratify his palate. The better the stock or stem on which the graft is placed, and the more nourishing its sap, the more likely is the fruit of the grafted plant to be good. What is called ennobling fruit-trees, is grafting on excellent and well-tried stocks. The same process is adopted in regard to other fruits, as, for instance, pears, grapes, peaches, and plums. By the process of grafting,

Fig. 134.—Fruit of Fig. This is a succulent stalk, curved so as to form a hollow receptacle, on which numerous flowers are placed, each bearing a single-seeded fruit resembling a seed.

there is for a time an arrestment in the growth of the slip; and it is not until it is fully united to the stock, and derives its nourishment from it, that it grows and produces fruit. If we sow the seed of any apple, however fine, in ordinary soil, and allow it to grow wild, it will revert to the original species, and will produce unpalatable crab-apples. Such is also the case with slips put into the soil. It is only by careful cultivation and grafting that the good varieties are kept up.

126. The flavour of our table-fruits depends on the presence of certain chemical ingredients. If these are not developed, then the fruit wants some of its characteristics. Even after trees have been grafted, they are apt to run to leaves in place of flowering and fruiting. In such cases pruning must be adopted, in order to prevent them from becoming rampant. By inflicting an injury on the tree—as by cutting a ring out of the bark, or by stopping its roots—gardeners often make barren fruit-trees become productive. The fruit when ripe is usually detached from the tree; but sometimes the fruit of one year remains until that of another is produced. Thus, in the orange-tree, we meet with ripe fruit, green fruit, and flowers at the same time. At times the fruit appears to be complete, and yet it contains no seeds. Thus seedless grapes and seedless oranges are often met with. In such cases, although the fruit has a fair

appearance, it cannot be said to be perfect, for it has not fulfilled the object of its production, namely, the propagation of the plant. High cultivation may have a tendency to induce this state, and it may perhaps depend occasionally on the age of the trees. Bullar states that the thinness of the rind of the St Michael orange, and its freedom from pips, is owing to the latter cause—the trees, when young, producing fruit with thick rinds and plenty of seeds.

127. From all that has been said relative to fruit, many important lessons may be drawn. Thus, man in his natural state brings no fruit to perfection (Luke viii. 14); it is, like the crab-apple, unfit for the Master's use. Hosea, in talking of Israel's attempts to exhibit fruit, says, "Israel is an empty vine; he bringeth forth fruit unto himself"—(x. 1.) It is only when grafted by the great Husbandman into the true Vine (John xv. 1), and into the oil-bearing Olive (Rom. xi. 24), that man can bring forth good fruit, even unto life eternal.—(John iv. 36.) Our blessed Lord says to his disciples, "As the branch cannot bear fruit of itself, except it abide in the vine; no more can ye except ye abide in me. I am the vine, ye are the branches: he that abideth in me, and I in him, the same bringeth forth much fruit; for without me ye can do nothing."—(John xv. 4, 5.) As the graft is kept in union with the stock by means of the clay which

has been applied by the gardener, so is the believer united to Christ by faith, which is the gift of God. The clay-cement keeps the parts together, but has no virtue in itself: so faith is the means of union to Christ—it shows that the Husbandman has been there. The believer has no merit in this; faith cannot save him (James ii. 14), or make him bring forth fruit. It is the union with the Stock which does this. Thus it is that his faith is not dead, being alone (James ii. 17); there is a real, vital engrafting, and faith is seen by the works which are the fruits of it. By the process of spiritual grafting he is, as it were, checked in his own growth, in his self-love, his self-righteousness, and all his sap comes from Christ. In Him are all his well-springs, and from Him alone he derives all the nourishment and support he needs. Thus it is that he flourishes and brings forth the fruit of the Spirit, containing its nine ingredients, "love, joy, peace, long-suffering, gentleness, goodness, faith, meekness, temperance" (Gal. v. 22, 23), every one of which is necessary for the perfect fruit. Some of these ingredients may abound more than others, thus, as it were, imparting a peculiar flavour; but all must be there in greater or less quantity. Love may be looked upon as resembling the substance coming from the stock which unites the graft to it. This love flows from Christ to the grafted believer. "As the Father hath loved me, so have I loved

you; continue ye in my love."—(John xv. 9.) Thus the union is formed, and he becomes identified with the Stock. This love will last through eternity. When the clay is removed in the case of an ordinary tree, the graft is found united to the stock; so when faith is swallowed up in sight, then the perfect union of Christ and his people is seen. Heaven has not to begin, but only to perfect the living intercourse of believers with Christ and with each other. While on earth they were all grafted into one Stock. They were all one in Christ, who has said, "Neither pray I for these alone, but for them also which shall believe on me through their word; that they all may be one; as thou, Father, art in me, and I in thee, that they also may be one in us: that the world may believe that thou hast sent me."—(John xvii. 20, 21.)

128. We have seen, in the case of fruit-trees, that pruning is often necessary in order to make them bear fruit well; so it is in spiritual fruit-bearing. Too often the believer becomes, as it were, rampant, is elated by worldly fame and reputation, or by the praise of men, and, like the ordinary vine, produces abundance of leaves, but no fruit. He then requires to be pruned, to be put into the furnace of affliction, to have those worldly things or those spiritual acquirements on which he rested lopped off; and thus purged (John xv. 2), he brings forth fruit to the glory of God. The

removal of comforts, the humbling of pride and self-complacency, all tend to make the fruit more precious. They constitute the spiritual pruning, the chastening which "yieldeth the peaceable fruits of righteousness" (Heb. xii. 11.) When the pruning-knife of affliction has cut off the luxuriant branches of pride and vain-glory, then is the Christian led in deep humility to see that there is no trusting in self. Christ then says to him, "From Me is thy fruit found" (Hos. xiv. 8), even that fruit which shall remain.—(John xv. 16.) As the fruit may have a great show, but contain no seed with the embryo spark of life, and thus fail in fulfilling the object for which it was formed; so there may be an appearance of spiritual fruit without the vitality of religion. Such fruit, though fair externally, is in reality dead, and fails in the hour of trial. Like seedless fruits, this spiritual state may be produced by human cultivation, by an artificial nourishment, by a fostering of self-righteousness. There has been no true grafting, no implanting of the heavenly life in the soul. While, however, seedless fruits are said to be sometimes naturally produced by old trees, this is not the case with the true Christian; for he continues to bear true fruit even in old age, being full of sap (Ps. xcii. 14), derived from the one true source of all fruitfulness, in whom it has pleased the Father that all fulness should dwell.—(Col. i. 19.)

129. *The Seed.* This is contained in the seed-vessel, or, in other words, in the fruit (fig. 123, *OV*, p. 160.) In order that it may be complete, it must contain the rudiment of the young plant, or what is called the embryo. On removing the skin of the seed, it is sometimes found that this embryo occupies the whole of the interior. This is the case in the bean, pea, and lupin, the fleshy cotyledons of which form the great bulk of the seed; so also in the common stock (fig. 135), and other plants of the cruciferous order, such as wall-flower and candytuft. At other times the embryo forms only a part of the seed, as in palms (fig. 136,

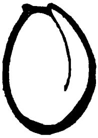


Fig. 135.

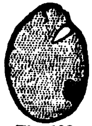


Fig. 136.


Fig. 137.

and fig. 50, p. 63), lychnis (fig. 137), wheat (fig. 58, p. 72), barley and oats (fig. 51, p. 64.) In these instances, there is a separate store of nourish-

Fig. 135.—Seed of Common Stock Gillyflower, cut open in a vertical manner, showing the embryo plant, of a white colour, occupying the whole of the interior. The coverings of the seed are dark, and a black line indicates the folding of the young root on the cotyledon.

Fig. 136.—Seed of a Palm, cut vertically, showing the minute white embryo occupying only a small part of it. The bulk of this seed is made up by a separate store of nourishing matter.

Fig. 137.—Seed of Red Campion (*Lychnis*), cut vertically, showing the embryo curved round the store of nourishment, which is in the centre.

ing matter, which, after the seed has been sown, is gradually dissolved, so as to be taken up by the plant in the early stages of growth.

130. The mode in which seeds are scattered is deserving of notice. In some cases the fruit falls without opening, and gradually decays, forming a sort of manure with the soil in which the plant sprouts. In other cases the seed-vessels open, and scatter the seeds. In the common broom, the pod,

Fig. 138.

Fig. 139.

when ripe, opens with considerable force; so also the fruit of the sandbox-tree, and the balsam, which is called Touch-me-not, on account of its seed-vessel bursting when touched. The squirting cucumber, when handled in its ripe state, gives

Fig. 138.—Fruit of Geranium, showing the different parts of which it is composed curling upwards, so as to scatter the seed.

Fig. 139.—Winged Seed of Common Fir.

way at the point where the fruit joins the stalk, and the seeds are sent out with amazing force. The common geranium seed-vessels curl up when ripe, as seen in fig. 138, and scatter the seeds. In the case of firs (fig. 139), bignonias, and some other plants, the seeds are furnished with winged appendages; while in the cotton-plant and asclepias, they have hairs attached to them, by means of which they are wafted to a distance. The action of moisture in opening seed-vessels has been alluded to in the case of a succulent species of fig-marygold (fig. 29, p. 44) from the Cape of Good Hope, and of the rose of Jericho.

131. In the case of composite plants, such as the dandelion, thistle, and artichoke, what is commonly called the seed is in reality the fruit with the calyx attached in the form of hairs (fig. 107, p. 146). Each fruit contains a single seed, and it is interesting to know the process by which this single-seeded fruit is deposited in the soil. In these plants there are numerous flowers on a common receptacle, which is at first succulent and nutritive. In the young state this receptacle contains much starch, which is gradully changed into sugar, so as to be easily taken up in solution by the flower. In the artichoke, it is then fit to be used for food. As the flower grows and the fruit is perfected, the receptacle loses its sugary matter and becomes dry. In this state it is useful for

food. Meanwhile the hairy calyx attached to the fruit increases so as to be ready to waft it to a distance. In the dandelion, the leaves which surround the clusters or heads of flowers (fig. 107, p. 146) are turned downwards, the receptacle becomes convex and dry, the hairs spread out so as to form a parachutelike appendage to each fruit, and collectively to present the appearance of a ball, and in this way the fruit is prepared for being dispersed by the winds. Transported by the agency of man and animals, and carried by means of winds and streams, seeds are deposited in situations fitted for their growth, and under the influence of heat, moisture, and air the young plant passes through all the stages of growth already described.

132. Such is a hasty glance at the various changes which take place in flowering plants, from the first sprouting of the embryo until the perfect seed is formed and scattered. The sketch would not be complete without a short notice of the same phenomena in flowerless plants. In them there are no distinct floral organs such as the calyx, corolla, stamens, and pistil. Certain cellular bodies, however, are found in them, by the union of which it would appear that reproductive germs, equivalent to seeds or to embryo plants, are formed. In ferns there are little clusters of minute bags, containing powdery matter or spores, having the power of germinating; those bags occur either on the back

of the leaves or fronds, as seen in the common lady-fern (fig. 42, p. 55), or in spikelike processes, as in the royal-fern. The cases or bags are often surrounded by elastic rings which open them and scatter the spores. In the common horsetail (*Equisetum*), the little germs or spores are surrounded by two filaments with each of their extremities swollen, as seen in fig. 140. These are remarkably hygrometric, and coil round the spore, as seen in fig. 141, when moisture is applied, but spread out when dry, as in fig. 140. They appear to be connect-

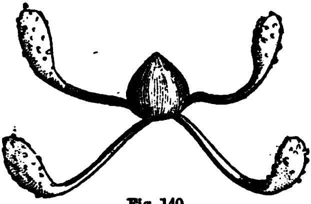


Fig. 140.

Fig. 141.

ed with the deposition of the spore in the soil, and placing it in circumstances fit for its growth. These spores form interesting objects under the microscope. When gently breathed upon, the filaments coil up in a remarkable way. In mosses, the reproductive organs are only seen in the young state. When fully developed, the germs or spores are con-

Fig. 140.—Spore of Horsetail (*Equisetum*), surrounded by two filaments with swollen extremities. These filaments are hygrometric.
Fig. 141.—The same spore with the filaments coiled round it.

tained in little urnlike cases *u* (figs. 142, 143, and 144), covered by a sort of veil *c*, which falls off and displays a lid *o*. When this lid is separated, as seen in fig. 144, *o*, there is displayed a series of

Fig. 142.

Fig. 143.

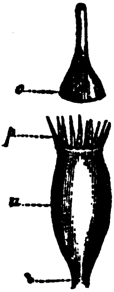


Fig. 144.

processes *p* called teeth, which are very hygrometric, rising up when dry and folding down

Fig. 142.—A moss (*Funaria hygrometrica*), slightly magnified. Leaves *f* connected with the stalk *p*; *u* urnlike spore case with its veil *c*, and lid *o*.

Fig. 143.—Urnlike case of a moss (*Encalypta vulgaris*) magnified; *s* stalk, *c* veil, under which and seen through it are *u* the urnlike spore case, and *o* the lid

Fig. 144.—Urnlike case *u* of the same moss with the veil removed, and the lid *o* taken off to show the row of teeth *p*; *s* the stalk bearing the case.

when moist. These teeth are either four or some multiple of four. They surround the top of the the case, which contains the spores in its interior. How beautiful is the structure of the smallest moss when fully examined. No wonder that Mungo Park, when seeing such a plant expanding itself in the desert, was led to contemplate with wonder the care which God takes of the minutest parts of creation, and to derive encouragement from this thought in his weary pilgrimage.

133. The little reproductive cells of lichens (fig. 1, p. 17) have already been alluded to when speaking of the mode in which they contribute to the vegetation of coral islands. So also have those of the mushroom tribe, when considering the production of mould (figs. 5, p. 19, and 28, p. 43). In seaweeds the reproductive germs are either arranged in clusters of four, or are contained in cases of various kinds. In the common seaweed (*Fucus vesiculosus*), as seen in fig. 145,

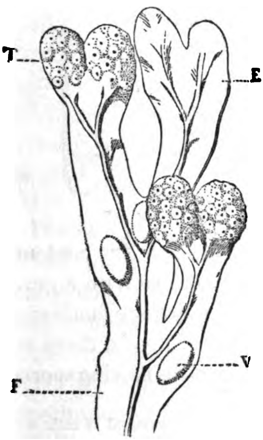


Fig. 145.

Fig. 145.—Frond *F E* of *Fucus vesiculosus* or common seaweed; *V* bladders of air; *T* cases containing spores and mucus.

the frond *FE* displays little bladders of air *V*, which enable it to float, and receptacles of germs *T*, associated with a slimy sort of mucus. Some of the fresh-water algæ are composed of simple rows of cells, as seen in fig. 146. These cellular filaments in some instances unite together, as seen in fig. 147, by

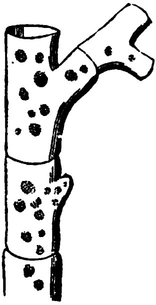


Fig. 146.

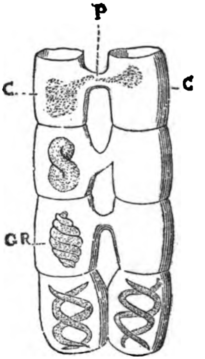


Fig. 147.

means of a tube *P*; and in this way the contents of one cell pass into another, so as to form a germ or spore *GR*. In those plants which are familiar to all as forming the green slime of ponds, there are moving filaments observed, as well as moving spores.

Fig. 146.—A Conferva, or fresh-water Alga, composed of cells with granular matter inside.

Fig. 147.—Two filaments of a fresh-water Alga (*Zygnema*) united by tubes *P*. The contents of one cell *C* pass into another cell *C* on the left, and thus the spore, as seen at *GR*, is produced. In the lowest cells moving thread-like bodies are seen, called phytozoa.

The latter, as represented in figs. 148, 149, and 150, are furnished with hair-like processes, which either come off from one point in clusters of two (fig. 148), or more (fig. 149), or surround the whole spore as with a fringe (fig. 150). These minute hairs

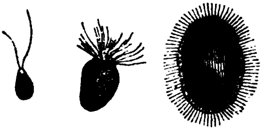


Fig. 148. Fig. 149. Fig. 150.

exhibit movements for a short time after the spores are separated from the plant; their vibration ceasing whenever the spore becomes fixed and begins to sprout. In some brittle algæ having flinty coverings, the cells divide so as to form new individuals.

134. In all the structures to which we have referred, and in the varied changes which the plant undergoes, how beautiful are the adaptations! Every thing is guided by unerring wisdom, and contributes to form one harmonious system, in which there is no flaw and no deficiency. All is superintended by an Omniscient Jehovah, whose

Figs. 148, 149, 150.—Spores or germs of Conferva and Vaucheria, showing vibratile hair-like processes. In fig. 148, two hairs are seen; in 149, several at one end; in 150, a fringe of hairs round the spore. These spores exhibit movements, and are hence called Zoospores. The movements cease when the spore fixes itself and begins to sprout.

care extends to the minutest atom. It is an erroneous view to think of God as governing the grand phenomena of nature, and leaving those which are minute to the operation of a set of laws which He does not uphold at every moment in all the fulness of their application. "We cannot," says Chalmers, "disjoin God from one particle of the universe, without desolating the universe of God." We may despise what is small as beneath the notice of our pride, but nothing is too microscopic for Him who, while "He measures the waters in the hollow of His hand, and metes out heaven with the span, and comprehends the dust of the earth in a measure, and weighs the mountains in scales, and the hills in a balance" (Isa. xl. 12), yet numbers the very hairs of our head, and knows of every sparrow that falls to the ground.—(Matt. x. 29, 30.) The minuteness with which God provides for all wants is well brought out in the 65th Psalm, where David speaks of Him as attending to the very settling of the furrows of the field and the watering of the ridges. "*Thou* makest the outgoings of the morning and evening to rejoice. *Thou* visitest the earth, and waterest it: *Thou* greatly enrichest it with the river of God, which is full of water: *Thou* preparest them corn, when *Thou* hast so provided for it. *Thou* waterest the ridges thereof abundantly: *Thou* settlest the furrows thereof: *Thou* makest it soft with showers: *Thou* blessest

the springing thereof. *Thou* crownest the year with Thy goodness; and Thy paths drop fatness." In the minutest events connected with the growth and development of plants, we may apply what David said of the structure of the human frame, "For Thou hast possessed my reins: Thou hast covered me in my mother's womb. I will praise Thee; for I am fearfully and wonderfully made: marvellous are Thy works; and that my soul knoweth right well. My substance was not hid from Thee, when I was made in secret, and curiously wrought in the lowest parts of the earth. Thine eyes did see my substance, yet being unperfect; and in Thy book all my members were written, which in continuance were fashioned, when as yet there was none of them."—(Ps. cxxxix. 13–16.)

CHAPTER III.

RELATION WHICH BOTANY BEARS TO VARIOUS DEPARTMENTS OF SCIENCE AND ART.

135. From what has been already stated, it may be seen that the science of botany, when prosecuted for its own sake, is well worthy of attention. It enables us to view the vegetable creation in a very different light from that in which we are apt to regard it. It leads us to contemplate even the commonest weed with sentiments of admiration and wonder; and it forces upon our attention the important lesson of our Lord, that "if God so clothe the grass of the field, which to-day is, and to-morrow is cast into the oven, shall He not much more clothe us."—(Matt. vi. 30.)

136. We see that many spiritual things are illustrated in the Bible by similitudes taken from natural things. Thus, in the thirteenth chapter of Matthew illustrations are taken from seed, tares, mustard seed, leaven, treasure in a field, a pearl, and a net. Trees, and other creatures of God's provi-

dence speak to us of the attributes and perfection of God. The invisible things of God are clearly seen, being understood by the things that are made, even His eternal power and Godhead.—(Rom. i. 20). All His works praise Him, (see Ps. cxlv. 10 and Ps. cxlviii.); they all speak a distinct language, they all have a voice to which man ought to listen.

137. How interesting are the associations connected with the practical prosecution of botany! Those who have joined in botanical excursions will appreciate the feelings of delight with which the floral treasures of the plain or of the mountain are gathered. "There is," says Dr George Johnston, "a preordained and beneficial influence of external nature over the constitution and mind of man. He who made nature all beauty to the eye, implanted at the same time in his rational creatures an instinctive perception of that beauty, and has joined with it a pleasure and enjoyment that operate through life. You have a proof of this in the gaiety of the infant swayed only by external influences,—in the child's love of the daisy and the enamelled fields,—in the girl's haunt by the primrose bank and rushy brook,—in the school-boy's truant steps by briery brake or flowery shaw, by trouting streams or nutting wood,—in the trysting tree and green leaves of love's age,—in the restless activity that sends us adrift in search of the pic-

turesque,—in the 'London pride' of the citizen,—in the garden of retired leisure,—in the prize flower that lends its interest to old age. We are all the better for our botanical walks, when undertaken in the right spirit; they soothe, soften, or exhilarate. The landscape around us becomes our teacher, and from its lesson there is no escape; we are wooed to peace by the impress of Nature's beauty, and the very air we breathe becomes a source of gratification and pleasure."

138. In giving an account of a botanical trip to Braemar, Clova, and other parts of the Scottish Highlands, I have elsewhere made the following remarks:*— Excursions may be truly said to be the *life* of the botanist. They enable him to study the science practically, by the examination of plants in their living state, and in their native localities; they impress upon his mind the structural and physiological lessons he has received; they exhibit to him the geographical range of species, both as regards latitude and altitude; and with the pursuit of scientific knowledge, they combine that healthful and spirit-stirring recreation which tends materially to aid mental efforts. The companionship too of those who are prosecuting with zeal and enthusiasm the same path of science, is not the least delightful feature of such excursions. The various phases of character exhibited, the pleasing

* Jameson's *Edinburgh Philosophical Journal,* July 1848.

incidents that diversified the walk, the jokes that passed, and even the very mishaps or annoyances that occurred,—all become objects of interest, and unite the members of the party by ties of no ordinary kind. And the feelings thus excited are by no means of an evanescent or fleeting nature; they last during life, and are always recalled by the sight of the specimens which were collected. These apparently insignificant remnants of vegetation recall many a tale of adventure, and are associated with the delightful recollection of many a friend. It is not indeed a matter of surprise, that those who have lived and walked for weeks together in a Highland ramble, who have met in sunshine and in tempest, who have climbed together the misty summits, and have slept in the miserable shieling—should have such scenes indelibly impressed on their memory.

139. There is, moreover, something peculiarly attractive in the collecting of *alpine* plants. Their comparative rarity, the localities in which they grow, and frequently their beautiful hues, conspire in shedding around them a halo of interest far exceeding that connected with lowland productions. The alpine Veronica, displaying its lovely blue corolla on the verge of dissolving snows; the Forget-me-not of the mountain summit, whose tints far excel those of its namesake of the brooks; the Woodsia, with its tufted fronds adorning the clefts

of the rocks; the snowy Gentian, concealing its eye of blue in the ledges of the steep crags; the alpine Astragalus, enlivening the turf with its purple clusters; the Lychnis, choosing the stony and dry knoll for the evolution of its pink petals; the alpine Sowthistle, raising its stately stalk and azure heads in spots which try the enthusiasm of the adventurous collector; the pale-flowered Oxytropis, confining itself to a single British cliff; the Azalea, forming a carpet of the richest crimson; the Saxifrages, with their white, yellow, and pink blossoms clothing the sides of the streams; the Saussurea and Erigeron, crowning the rocks with their purple and pink capitula; the pendent Cinquefoil, blending its yellow flowers with the white of the alpine Cerastiums and the bright blue of the stony Veronica; the stemless Silene, giving a pink and velvety covering to the decomposing granite; the yellow Hieracia, whose varied transition-forms have furnished such a fertile cause of dispute among botanists; the slender and delicate grasses, the chickweeds, the carices, and the rushes, which spring up on the moist alpine summits; the graceful ferns, the tiny mosses, with their urnlike thecæ, the crustaceous dry lichens, with their spore-bearing apothecia,—all these add a charm to botanical excursions, impressing them indelibly on the memory, and associating them with objects of the most pleasing nature.

I.—BEARINGS OF BOTANY ON GEOLOGY.

140. Botany has an important relation to Geology. It enables the geological inquirer to ascertain the nature of the plants which are found imbedded in various rocks, and furnishes him with the means of ascertaining the mode in which these rocks were formed, and the state of the globe at the epoch when they were deposited. "Geology," says Professor Phillips, "would never perhaps have escaped from the domain of empiricism and conjecture, but for the innumerable testimonies of elapsed periods and perished creations which the stratified rocks of the globe present in the remains of ancient plants and animals. So many important questions concerning their nature, circumstances of existence, and mode of inhumation in the rocks, have been suggested by these interesting remains; and the natural sciences have received so powerful an impulse, and been directed with such great success to the solution of problems concerning the past history of the earth, that we scarcely feel disposed to dissent from the opinion, that without fossil zoology and botany, there would have been no true geology."

141. In studying this department of botany, attention must be paid not merely to external forms, but also to minute structure. In many of the fossil-plants, the cells and vessels which enter

into their composition may be detected by the microscope. Mr William Nicol of Edinburgh was the first to make those sections of fossil-woods which have contributed so much to the advance of our knowledge. In many of the trees found in the sandstone near Edinburgh, as at Craigleith and Granton, distinct disc-bearing woody fibres (fig. 151) have been seen, plainly indicating, along with other characters, that they belong to the cone-bearing tribe, and more especially that they are allied to the Australian *Altingias*, as represented in fig. 71, p. 91. The presence of vessels with ladder-like bars on their walls (fig. 152), have led to the determination of stems of ferns. Besides the elementary tissues and the general forms of plants, it is necessary that the geologist should attend to the scars left by the removal of leaves, to the markings on the bark, and to the character of the fruit, for on all these points the knowledge of fossil-plants depends. There must also be combined with all this a correct idea of the

Fig. 151.

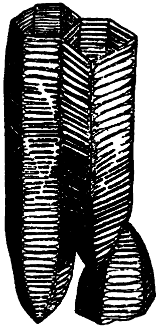


Fig. 152.

Fig. 151.—Woody fibre of a coniferous plant, showing rounded disc-like markings. These are seen in many fossil woods.

Fig. 152.—Scalariform or ladder-like vessels of ferns.

nature of plants as regards the localities and climates in which they grow. There must be the means of distinguishing between plants of salt and those of fresh water, between plants of marshes and those of dry land, between plants of estuaries and those of mountains, between plants of warm and those of cold climates. On such facts as these, the determinations of the geologist are founded.

142. "In the beginning God created the heavens and the earth" (Gen. i. 1); but when the beginning was, we know not. No information is given in the Bible as to the state of the globe before the ushering in of its present condition, when "it was without form, and void, and darkness was upon the face of the deep." It only tells us of God's work during six days, and his rest on the seventh. There are, however, distinct indications in the crust of the earth that it has undergone various changes during the time that it was being prepared by the Almighty for the habitation of man. Not the least important data on which these conclusions are based, are the presence of fossil-plants of various kinds, and in different rocks.

143. The vegetation which covered the earth has been altered in its character at different geological epochs. All the plants which have been discovered in a fossil state may be referred more or less evidently to the great divisions of the vege-

table kingdom of the present day—the dicotyledons, monocotyledons, and acotyledons. The farther we go back in geological epochs, the more do the species of plants differ from those of the present epoch. In the most ancient times, it appears that the prevailing vegetation was that of plants allied to ferns; next comes a period when plants resembling the cone-bearing of the present day had the ascendency; and finally, we reach the epoch when plants like our ordinary monocotyledons and dicotyledons predominated.

144. In all the phenomena connected with the different fossil floras, there is no evidence of what some have called a progressive development; nor is there any thing to favour the idea that species have risen in the scale by being transmuted into others. Those who have enunciated these sentiments, have proceeded upon a bad foundation. Their so-called facts have been mere illusions of the imagination. Thus they support their conclusions by stating that oats may be converted into rye by a constant process of pruning. This so-called fact, however, is a mere fiction of their own coining, and is not corroborated by any botanist. There seems to be a capacity in species to accommodate themselves to a certain extent to a change of external circumstances. Thus changes in appearance and structure arise, some of which are capable of being transmitted to the offspring.

These changes or variations, however, are not indefinite, but are regulated by certain fixed laws. Hence Whewell remarks :—" Indefinite divergence from the original type is not possible; and the extreme limit of possible variation may usually be reached in a short period of time. In short, species have a real existence in nature, and a transmutation from one to another does not exist."

145. " On the hypothesis of transmutation, in order to account for the seeming adaptation of the endowments of animals to their wants, it is maintained that the endowments are the result of the wants; and that the most striking attributes of animals, those which apparently imply most clearly the providing skill of their Creator, have been brought forth by the long-repeated efforts of the creatures to attain the object of their desires. Thus animals, it is said, with the highest endowments have been gradually developed from ancestral forms of the most limited organization: thus fish, birds, and beasts have grown from small gelatinous bodies, possessing some obscure principle of life and the capacity of development; and thus man himself, with all his intellectual and moral, as well as physical privileges, has been derived from some creature of the ape or baboon tribe, urged by a constant tendency to improve, or at least to alter his condition. Every part of the scheme is extremely arbitrary. The capacity for change, and

of being influenced by external circumstances, such as we really find it in nature, and therefore such as in science we must represent it, is a tendency not to improve, but to deteriorate. When species are modified by external causes, they usually degenerate, and do not advance; and there is no instance of a species acquiring an entirely new sense, faculty, or organ in addition to or in place of what it had before. Hence, on a full consideration of the whole subject, the conclusions to which we arrive are, that not only is the doctrine of transmutation of species in itself disproved by the best physiological reasonings, but the additional assumptions which are requisite to enable its advocates to apply it to the explanation of the geological and other phenomena of the earth, are altogether gratuitous and fantastical." The ablest refutation of these erroneous views, and the full exposition of their tendency to pervert truth, is given by Hugh Miller, in his excellent work, entitled "The Footprints of the Creator."*

146. Three marked epochs have been noticed by fossil-botanists, characterized by the predominance of certain great divisions of plants: 1, The reign of acrogens; 2, The reign of gymnosperms, or naked-seeded dicotyledons; 3, The reign of angio-

* See also Whewell's "Indications of the Creator," and Sedgwick's "Discourse on the Studies of the University of Cambridge."

sperms, or of monocotyledons and dicotyledons, with seeds in seed-vessels.

147. *The Reign of Acrogens.* In this epoch the

Fig. 153. Fig. 154. Fig. 155.

families of ferns and their allies predominated, so far as we can judge by the fossil remains. Besides

Fig. 156. Fig. 157. Fig. 158.

Fig. 153.—*Neuropteris Loshii,* a fossil-fern of the Coal Epoch.
Fig. 154.—*Neuropteris gigantea,* another fern of the same epoch.
Fig. 155.—*Neuropteris acuminata,* do. do.
Fig. 156.—*Sphenopteris affinis,* do. do.
Fig. 157.—*Pecopteris heterophyllus,* do. do.
Fig. 158.—*Sphenopteris dilatata,* do. do.

these, however, there were many specimens of coniferous or cone-bearing dicotyledons. This embraces the great coal formation. Some of the plants connected with this period of the earth's history are seen in figs. 153 to 162. These repre-

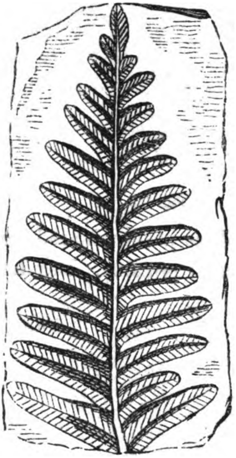


Fig. 159.

Fig. 160.

sent various species of extinct ferns, and their allies. The ferns belong to the genera *Neuropteris*, *Sphenopteris*, and *Pecopteris* (figs. 153–159);—their allies being *Lepidodendron* (fig. 160), *Sigillaria*

Fig. 159.—*Pecopteris aquilina*, a fossil-fern of the Coal Epoch.

Fig. 160.—*Lepidodendron elegans*, a fossil of the Coal Epoch, allied to *Lycopodiums* of the present day.

(figs. 161, 162), *Calamites* (fig. 163) resembling in

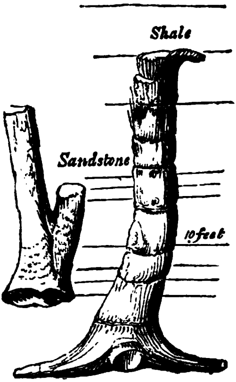


Fig. 161.

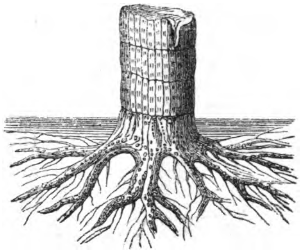


Fig. 162.

some respects horsetails, and *Stigmaria* (fig. 164), which may perhaps be the roots of *Sigillaria*.

148. Coal is well ascertained to be of vegetable origin, and was probably formed by the compression of immense trunks of acrogens and of other trees which were drifted into large troughs or basins by the action of water. It is rare to find any distinct vegetable structure in coal, in consequence of the change produced by the compressing force to which it has been subjected. In some kinds of coal, however, cellular and other structures have been detected, on examining sections of them under the

Figs. 161, 162.—*Sigillaria pachyderma*, a fossil of the Coal Epoch, allied to ferns.

microscope. The mass of vegetation concerned in the formation of our coal beds must have been enormous. The prospective beneficence of the Creator is seen in covering the earth at that epoch of its history with a luxuriant vegetation, and in storing it up in subterranean strata as enduring beds of coal, which, by the subsequent volcanic actions, have been rendered accessible to man, and have become to him in these later days the source of heat and light. Thus, while the surface of the earth is given to man whence to obtain his food,

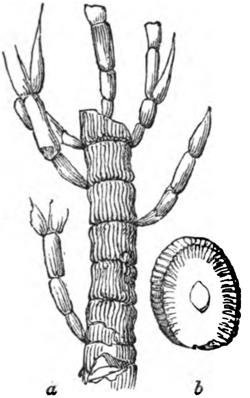


Fig. 163.

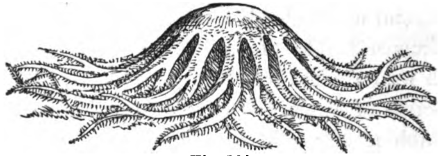


Fig. 164.

the substrata are made to furnish that material

Fig. 163.—*Calamites Mougeotii*, a jointed stem, resembling that of an Equisetum in some respects, but differing in having an apparent bark;—*a*, branching-stem; *b*, partition of one of the joints.

Fig. 164.—*Stigmaria ficoides*, a plant very abundant in the Coal Measures, supposed by some to be the roots of Sigillaria.

which is required to dress it, and to raise man in the scale of civilization.

149. In speaking of the Bohemian coal mines, Buckland remarks, "The most elaborate imitations of living foliage upon the painted ceilings of Italian palaces, bear no comparison with the beauteous profusion of extinct vegetable forms with which the galleries of these instructive coal mines are overhung. The roof is covered as with a canopy of gorgeous tapestry enriched with festoons of most graceful foliage, flung in wild and irregular profusion over every portion of its surface. The effect is heightened by the contrast of the coal-black colour of these vegetables with the light groundwork of the rock to which they are attached. The spectator feels himself transported, as if by enchantment, into the forests of another world; he beholds trees of forms and characters now unknown upon the surface of the earth, presented to his senses, almost in the beauty and vigour of their primeval life; their scaly stems (fig. 160, p. 194), and bending branches with their delicate apparatus of foliage, are all spread forth before him, little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation, which began and terminated in times of which these relics are the infallible historians. Such are the grand herbaria wherein these most ancient remains of the vegetable kingdom are preserved, in a state

of integrity little short of their living perfection, under conditions of our planet which exist no more."

150. The vegetation of the Coal Epoch seems to resemble most that of islands in the midst of vast oceans, and the prevalence of ferns indicates a climate similar to that of New Zealand in the present day. In speaking of the island vegetation of the Coal Epoch, Professor Ansted remarks:—"The whole of the interior of the islands may have been clothed with thick forests, the dark verdure of which would only be interrupted by the bright green of the swamps in the hollows, or the brown tint of the ferns covering some districts near the coasts. The forests may have been formed by a mixture of several different trees. We would see then, for instance, the lofty and widely-spreading Lepidodendron (fig. 159, p. 194), its delicate, feathery, and mosslike fronds clothing, in rich luxuriance, branches and stems which are built up, like the trunk of the tree fern, by successive leaf-stalks that have one after another dropped away, giving by their decay additional height to the stem, which might at length be mistaken for that of a gigantic pine. There also should we find the Sigillaria (figs. 161, 162, p. 195), its tapering and elegant form sustained on a large and firm basis, enormous matted roots, almost as large as the trunk itself, being given off in every direction, and shooting out their

fibres far into the sand and clay in search of moisture. The stem of this tree would appear like a fluted column, rising simply and gracefully without branches to a great height, and then spreading out a magnificent head of leaves like a noble palm-tree. Other trees more or less resembling palms, and others like existing firs also abounded, giving a richness and variety to the scene; while one gigantic species, strikingly resembling the Norfolk Island pine (fig. 71, p. 91), might be seen towering a hundred feet or more above the rest of the forest, and exhibiting tier after tier of branches richly clothed with its peculiar pointed spearlike leaves, the branches gradually diminishing in size as they approach the apex of a lofty pyramid of vegetation. Tree ferns (fig. 25, p. 40) also in abundance might there be recognised, occupying a prominent place in the physiognomy of vegetation, and dotted at intervals over the distant plains and valleys; the intermediate spaces being clothed with low vegetation of more humble plants of the same kind. These, we may imagine, exhibiting their rich crests of numerous fronds, each many feet in length, and produced in such quantity as to rival even the palm trees in beauty. Besides all these, other lofty trees of that day, whose stems and branches are now called Calamites, existed chiefly in the midst of swamps, and bore their singular branches and leaves aloft with strange

and monotonous uniformity. All these trees, and many others that might be associated with them, were perhaps girt round with innumerable creepers and parasitic plants, climbing to the topmost branches of the most lofty amongst them, and enlivening, by the bright and vivid colours of their flowers, the dark and gloomy character of the great masses of vegetation."

151. "Few persons," says Buckland, "are aware of the remote and wonderful events in the economy of our planet, and of the complicated applications of human iudustry and science, which are involved in the production of the coal that supplies the metropolis of England. The most early stage to which we can carry back its origin, was among the swamps and forests of the primeval earth, where it flourished in the form of gigantic Calamites, and stately Lepidodendra, and Sigillariæ. From their native bed, these plants were torn away by the storms and inundations of a hot and humid climate, and transported into some adjacent lake, or estuary, or sea. Here they floated on the waters, until they sank saturated to the bottom, and being buried in the detritus of adjacent lands, became transferred to a new estate among the members of the mineral kingdom. A long interment followed, during which a course of chemical changes, and new combinations of their vegetable elements, have converted them into the mineral condition of

coal. By the elevating force of subterranean fires, these beds of coal have been uplifted from beneath the waters, to a new position in the hills and mountains, where they are accessible to the industry of man. From this fourth stage in its adventures, our coal has again been moved by the labours of the miner, assisted by the arts and sciences, that have co-operated to produce the steam engine and the safety lamp. Returned once more to the light of day, and a second time committed to the waters, it has, by the aid of navigation, been conveyed to the scene of its next and most considerable change by fire; a change during which it becomes subservient to the most important wants and conveniences of man. In this seventh stage of its long eventful history, it seems to the vulgar eye to undergo annihilation; its elements are indeed released from the mineral combinations they have maintained for ages, but their apparent destruction is only the commencement of new successions of change and of activity. Set free from their long imprisonment, they return to their native atmosphere, from which they were absorbed to take part in the primeval vegetation of the earth. To-morrow, they may contribute to the substance of timber, in the trees of our existing forests; and having for a while resumed their place in the living vegetable kingdom, may ere long be applied a second time to the use and benefit of man. And when decay or fire

shall once more consign them to the earth, or to the atmosphere, the same elements will enter on some further department of their perpetual ministration in the economy of the material world."

152. *The Reign of Gymnosperms.* During the epoch between that last noticed and the chalk period, the vegetation seems to have undergone a marked change. Acrogens are less numerous, and dicotyledonous plants, having seeds not contained in ovaries, and hence called naked-seeded, predominate. These plants are represented by cone-bearing trees, such as pines, where the cones containing the seeds are not considered as ovaries, but as composed of scales or leaves bearing seeds at their base. They are also represented by the Cycas family, or plants yielding a kind of sago, which are shown in figs. 165, 166. These plants bear naked seeds on the edges of transformed

Fig. 165.

Fig. 165.—*Cycas revoluta,* one of the naked-seeded dicotyledons, resembling those which characterized the reign of Gymnosperms.

leaves. They have no true pistil, and the pollen is applied directly to the seed. Some of the stems of the fossil Cycads occur in an erect position in

Fig. 166.

what is denominated the Portland Dirt-bed, consisting of earthy brown matter of a peculiar character.

153. *The Reign of Angiosperms.* This includes the epoch which commences with the chalk and ends at the conclusion of the tertiary period, or that immediately preceding the present flora of

Fig. 166.—*Zamia* or *Encephalartos pungens*, another plant of the Cycas tribe, having naked seeds, and hence called gymnospermous.

the globe. There is a predominance in this epoch of plants resembling more nearly those of the present day. These belong chiefly to the divisions of monocotyledons and dicotyledons, having seed-vessels, and hence called angiosperms.

154. Thus all the phenomena connected with fossil plants, show that great changes have taken place in our planet during its preparation for the abode of man, the noblest of God's works on earth; and they lead us to think of that final change when the earth shall be renewed and made a habitation of righteousness and peace. "But the day of the Lord will come as a thief in the night; in the which the heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also, and the works that are therein, shall be burnt up. Seeing then that all these things shall be dissolved, what manner of persons ought ye to be in all holy conversation and godliness; looking for and hasting unto the coming of the day of God, wherein the heavens, being on fire, shall be dissolved, and the elements shall melt with fervent heat? Nevertheless we, according to His promise, look for new heavens and a new earth, wherein dwelleth righteousness. Wherefore, beloved, seeing that ye look for such things, be diligent that ye may be found of Him in peace, without spot, and blameless."—(2 Peter iii. 10–14.)

155. "In prosecuting our geological researches in a right spirit, we need not fear that we shall ever arrive at a point where the knowledge of nature will be found to be at variance with the truth of Scripture. The volume of Nature and the volume of Inspiration are the products of the same Omniscient Mind. God is the author of both; and the more thoroughly each is studied, the more shall we be constrained to admit the unnumbered harmonies which subsist betwixt the two, and the beautiful light of illustration which they reciprocally shed on one another. Founding on this simple consideration of the common authorship of the two volumes, we may discard every jealousy of true science, and say with confidence that Christianity has every thing to hope and nothing to fear from the advancement of philosophy. There is a knowledge of nature which is essentially atheistic, but this arises not from superabundance, but from defect of knowledge; not from its going beyond, but from its stopping short of its legitimate bounds." All the discoveries of geology tend only to confirm the statements of Scripture, as has been ably shown by Dr King in his volume on the connection between Geology and Religion.

156. On the subject of Bible teaching in reference to the laws of nature, the following remarks of Gaussen deserve to be studied:—"Open the Bible, examine the fifty sacred authors therein, from

Moses—who wrote in the wilderness 400 years before the siege of Troy—to the fisherman son of Zebedee, who wrote 1500 years later in Ephesus and Patmos, under the reign of Domitian; and you will find none of those mistakes which the science of every country detects in the works of preceding generations. Carefully go through the Bible from Genesis to Revelation, in search of such faults, and as you carry on the investigation, remember that it is a book which treats of every thing, which describes nature, which recounts its wonders, which records its creation, which tells us of the formation of the heavens, of the light, of the waters, of the air, of the mountains, of animals, and of plants;—that it is a book which acquaints us with the first revolutions of the world, and which foretells also its last;—that it is a book which describes them with circumstantial details, invests them with sublime poetry, and chants them in fervent melodies;—that it is a book replete with eastern imagery, full of majesty, variety, and boldness;—that it is a book which treats of the earth and things visible, and at the same time of the celestial world and things invisible;—that it is a book in which nearly 50 writers, of every degree of cultivation, of every order, of every condition, and separated from one another by 1500 years, have been engaged;—that it is a book written variously in the centre of Asia, in the sands of Arabia, in

the deserts of Judea, in the porches of the Jewish Temple and in the rustic schools of the prophets of Bethel and Jericho, in the magnificent palaces of Babylon and on the idolatrous banks of the Chebar, and afterwards in the centre of western civilization, in the midst of the Jews and their ignorant councils, among polytheism and its idols, and as it were in the bosom of pantheism and its foolish philosophy;—that it is a book whose first writer was, during forty years, brought up among the magicians of Egypt, who regarded the sun, planets, and elements as endowed with intelligence, reacting upon and governing our world by their continual evaporation ;—and that it is a book whose first pages preceded, by more than 900 years, the most ancient philosophers of Greece and Asia, Thales, Pythagoras, Zaleucus, Xenophon, and Confucius;—that it is a book which carries its records into the scenes of the invisible world, the hierarchy of angels, the latest periods of futurity, and the glorious consummation of all things. Well, search in its 50 authors, its 66 books, its 1189 chapters, and its 31,173 verses,—search for a single one of the thousand errors with which every ancient and modern author abounds, when they speak of the heavens or of the earth, of their revolutions or their elements, and you will fail to find it. . . . . . It never does violence to facts, nor to the principles of sound natural philosophy. Never in

one single instance will you find it in opposition to the just ideas which science has given us, regarding the form of our globe, its magnitude, and its geology. . . . . There is, therefore, no physical error whatever in the Scriptures; and this transcendant fact, which becomes more admirable in proportion as it is made the subject of closer investigation, is a striking proof of the inspiration which dictated them, even to their least expressions."

157. *Effects of Plants on the sand of the shore, and on the mud of rivers.* Even at the present geological epoch, plants are concerned in the changes which are taking place in the soil of our globe. Many of them are beneficially employed in preventing the encroachments of the sea on the land, and in fixing the loose soil of our shores. The roots and underground stems of plants growing in these situations extend themselves widely in all directions in search of food, and thus become interwoven together so as to sustain the soil in a sort of basket-work, and consolidate the sands thrown up by the waves of the ocean. This is well seen in the case of the common bent or marram of our shores, and in some of the species of carex growing in the sand (fig. 167.) The great sea-dyke which prevents the inundation of Holland is said to owe its stability in a great measure to the plants which grow upon it. Plants also increase the quantity of dry land by growing

in the mud deposited by rivers at their mouth. The quantity of mud carried down by rivers at the

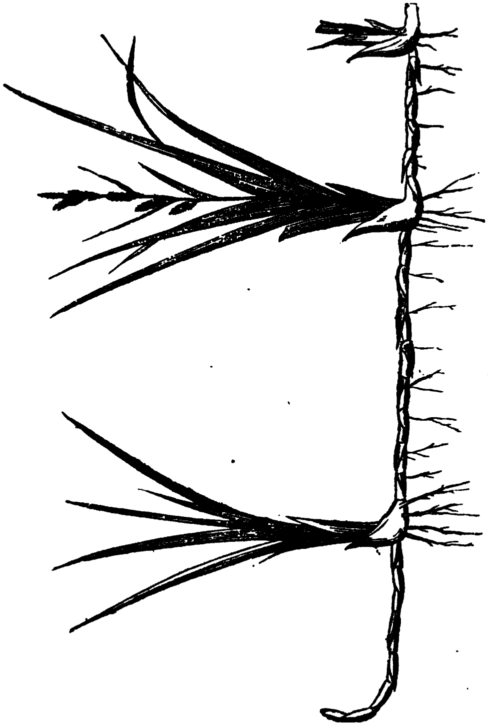


Fig. 167.

present day is immense. Ansted states that the

Fig. 167.—Sand Carex (*Carex arenaria*), **which with its underground stems and roots tends to consolidate the sands on the seashore.**

Rhine at Bonn has been calculated to carry down 400 tons of solid matter per hour; and in the course of one year 7000 to 8000 millions of tons. The whole of the Delta of the Ganges, comprising 20,000 square miles, has been formed by that river and its tributaries. The quantity of mud carried down in the rainy season is so great, that it may be detected 60 miles from the coast. In the flood season, Major Rennel calculates that 450 millions of tons of mud are brought down by the Ganges daily. It is said that the muddy nature of the Amazon may be seen in the ocean at the distance of 300 miles from its mouth. This mud, when deposited, is speedily taken possession of by plants, and thus its stability is secured. Out of the deposits of the Rhine the greater part of Holland has thus been formed, and out of those of the Po a large portion of the Venetian territory has arisen. The papyrus of the ancients, the bulrush of the Scriptures (fig. 39, p. 52), has contributed in no small degree to form the Delta of the Nile; and the mangrove trees of the present day are thus contributing to the formation of new land in tropical countries. The seeds of the mangrove germinate before being detached from the branches, and when they drop into the loose mud in which the plant grows, they immediately become trees with singular stems (fig. 168), which divide near the base, and allow the water of the tide and the

rivers to flow freely between them. By the double agency of roots and germinating seeds there is thus a very rapid acquisition of new land, which, although swampy and unwholesome at first, ultimately may be made fit for the habitation of man.

> "And such the mangrove, which, at full-moon flood,
> Appeared itself a wood upon the waters,
> But when the tide left bare its upright roots,
> A wood on piles suspended in the air."

We find man himself pursuing the same system, and, whether he knows or not that he is imitating nature, sowing vegetation to secure and consolidate the mud which his piers and dams have detained, that he may gain a new territory from the waters, or to arrest the progress of the sands which might be blown by the wind so as to injure the land. Thus does the marsh at length become a plain fitted for pasturage and agriculture, and the sands are consolidated and prevented from shifting.

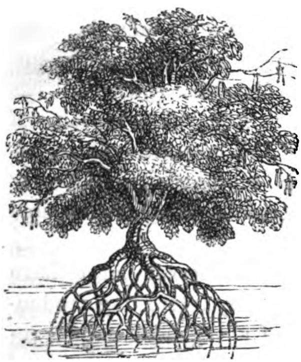


Fig. 168.

Fig. 168.—Mangrove tree (*Rhizophora Mangle*) of the tropics, with its singularly divided stem, growing in the mud at the mouths of rivers.

II.—BEARINGS OF BOTANY ON ZOOLOGY.

158. The lowest tribes of plants become in an especial manner an object of study to the zoological inquirer, in consequence of the great similarity which exists between them and the lowest tribes of animals. For, while there are wide and marked differences between the higher plants and animals, the lowest members of these two kingdoms of nature approach so nearly, that it is difficult to tell where the one begins and the other ends. Thus sponges, which are considered as belonging to the lowest class of animals, were at one time looked upon as vegetables; and the common coralline (*Corallina officinalis*), has been lately transferred from the domain of the zoologist to that of the botanist. Some bodies which Ehrenberg represents as infusory animals, are now considered as being of vegetable origin.

159. The most careless observer must have noticed on the seashore many interesting productions, to all appearance of a vegetable nature, resembling plants in their form and habits;—some of them being arborescent in their mode of growth, and fixed by roots to rocks, stones, and other substances, in the same manner as sea-weeds. The opinions of naturalists were long divided concerning these bodies, and we are indebted to the work

of Mr John Ellis on Corallines for the proof of their animal nature.

> "Involved in sea-wrack here we find a race
> Which science, doubting, knew not where to place;
> On shell or stone is dropp'd the embryo seed,
> And quickly vegetates a vital breed."

There are still, however, many productions which occupy an intermediate space between the animal and vegetable kingdom, and for the time being the zoologist and botanist must consent to joint occupancy. The existence of movements is by no means sufficient to form a line of demarcation, for many true sea-weeds exhibit distinct motions in their spores; and it has been recently stated that analysis can do little to help us in many cases; for cellulose, which has been long considered as characteristic of plants, has recently been detected in the structure of the tunics of the animals called Ascidians. Thus, whether we regard structure, functions, or chemical composition, we encounter great difficulties in distinguishing between the lowest members of the animal and vegetable kingdoms, and much still requires to be done ere we can come to any satisfactory conclusion.

160. Some of the minute plants called Diatoms, which are on the confines of the animal kingdom, occur in enormous quantity. Thus myriads of them are found in the mud at the mouths of rivers, in the bottom of the ocean, and in various deposits

of peat and sand on the surface of the globe. In some peat lately sent from Cantyre by the Duke of Argyle, there have been found at least fifty species of diatoms in immense quantity. Such is also the case with peat in Ireland, examined by the Rev. Wm. Smith, and peat at Premnay, Aberdeenshire, examined by Professor Dickie. The same species are widely diffused, and they seem to be capable of enduring great extremes of heat and cold. They were discovered in millions in pancake ice and in the deep soundings in the highest latitudes reached by the antarctic expedition, and they also occur in vast numbers on the branches of trees in the virgin forests of South America.

161. It would appear, from the researches of Ehrenberg, that in the atmosphere we breathe there are numerous species of diatoms which are carried by the winds and deposited in various spots. The immense quantity of matter so transported is proved by the various instances of black and coloured rains, arising from smoke, pollen, or other substances, which have been conveyed often to a great distance; and there is no doubt that myriads of minute species of fungi and other cryptogamous plants are thus diffused. The sirocco and trade-winds convey organisms for hundreds of miles. These have been found by Ehrenberg to be myriads of infusorial animals and diatomaceous plants. Clouds of dust sometimes colouring the atmosphere

orange or ochre, have been observed. These clouds of dust occur within the course of the trade-winds, and have been seen coming in various directions from the coast of Africa, as at Malta, Genoa, Lyons, and Silesia. The dust consists of various land and fresh-water diatoms, the flinty spicula of sponges and other zoophytes, pollen-grains, fragments of phanerogamous plants, such as hairs, cuticle, and various internal parts of structure, and some spores of fungi. The matters contained in these currents may lead to interesting observations as to the direction of winds, and various meteoric phenomena. Coloured snow in the Tyrol has been shown to be in some instances due to the same cause as coloured rain. What have been called showers of blood are, in reality, nothing but the sudden growth of palmella cruenta, one of the lower plants at the base of damp walls. Black rain fell in Ireland in April 1849 over a district of 700 square miles, and was due to portions of decayed plants mixed with diatoms.

III.—BEARINGS OF BOTANY ON MEDICINE IN ITS VARIOUS DEPARTMENTS.

162. To students of medicine, botany is valuable in many points of view. In some respects it may be looked upon rather as an ally than as a province of medicine—as a connecting link between

professional and purely scientific studies. It is too often supposed that botany is of little use to the student of medicine, and that all he acquires by his attendance at botanical lectures is a knowledge of the names, classes, and orders of medicinal plants. On this subject, Professor Edward Forbes remarks, "That the true object of the connection of natural history studies with more professional pursuits is frequently lost sight of. The object of these sciences is not merely to teach the student a certain number of facts, the recollection of which may be useful to him in after life; but the training his mind, by means of the peculiar forms of research which characterize those sciences, to that tone and vigour which must be of the utmost consequence in giving him power for future and professional avocations of a different character, especially such as are to form the after occupation of the student of medicine. A judicious practioner requires accurate observation and acute diagnosis, and these qualities are constantly brought into vigorous exercise in the prosecution of botanical investigations."

163. A medical man ought not to rest satisfied with a knowledge of the purely practical parts of his profession. His mind ought to be well stored with literary and scientific information; and were more attention paid to these studies, the profession generally would occupy a higher position than it does at present. The Commissioners for visiting

the Universities of Scotland make the following statement in their report:—"It is a matter about which all are agreed, that it is desirable that medical practitioners should be men of enlightened minds, accustomed to exert their intellectual powers, and familiar with habits of accurate observation and cautious reflection. It is also desirable that they should have that degree of literary attainment which will prevent them, when mingling as they must do with mankind in the exercise of their profession, from being looked upon with contempt, or from committing errors in conversation and in writing, for which others would be despised: because, even upon the supposition that, notwithstanding this, they have high professional acquisitions, the law of association will operate, and the conclusion will be drawn, that much confidence cannot be placed in them. This tendency not to confide in him, is one of the most formidable difficulties with which a physician has to struggle; much, unquestionably, of the success of ordinary practice depending upon the feelings of trust or security with which he is regarded. It is also of importance that a class of men so widely diffused, and mingling so much with society, as the members of the medical profession, should be so instructed as to be able to give a tone to conversation, and to promote among those with whom they associate the love and the pursuit of literary and scientific accomplishments."

164. Placed as a medical man frequently is in circumstances where he cannot have all the usual remedies at hand, he may be enabled, by his acquaintance with the structure and alliances of plants, to substitute with certainty one species for another. He may also be able to give an opinion as to their poisonous or esculent qualities, and may thus materially aid in the preservation of the life of a crew on a foreign and unknown shore. All who study the functions of the human body, will find it to their advantage to become in the first instance acquainted with the vital phenomena presented by plants. Many of the processes carried on in plants are more easily studied; and from an examination of them, important aid has been given to the science of human physiology. All classes of living beings must be embraced in the inquiries of the student who would become a scientific physiologist.

165. To the organic chemist who examines the mode in which the functions of living bodies are carried on, plants present objects of high interest. They may be looked upon as the great laboratories of nature, by means of which the materials of the atmosphere and the soil are rendered fit for the nourishment of man and animals. They constitute the herbage upon which animals feed, and they elaborate the nutritious matter from which our bread is prepared. Moreover, they act an impor-

tant part in those atmospheric changes which are essential for the process of respiration. The life of plants is intimately connected with that of animals. The presence of a rich and luxuriant vegetation may be conceived without the concurrence of animal life, but the existence of animals is undoubtedly dependent on the life and development of plants.

166. Although chemistry has enabled us to explain many of the changes which take place in the soil and atmosphere, by the agency of plants, still much is wanting ere we can understand the processes of assimilation which go on in the vegetable tissues. A blade of grass, says Dr Brown, (that yet mysterious community of parts, so consummate in living oneness) imbibes the moisture of the earth, inhales the fixed air and the ammonia of the atmosphere, and weaves its own expanding form, with all its delicate organs and their susceptibilities, out of their dismembered particles. By a similar but more wondrous alchemy is the herbage of the fields transformed into the quivering fibre of still higher and higher forms of animated existence. And of all these stupendous operations we know absolutely nothing. Water, carbonic acid, and ammonia are traced into the vessels of plants, but no farther. An organism dies, and once more falls down into the ammonia, carbonic acid, and water, from which it sprang. The chemist does all he can

to investigate these changes, but he has not been able to explain the process of organization.

IV.—BEARINGS OF BOTANY ON AGRICULTURE, HORTICULTURE, AND THE ART OF DESIGN.

167. To the student of agriculture, botany presents an important field of inquiry. The knowledge of the mode in which plants germinate and derive nourishment, aids him in the various operations of draining, ploughing, sowing, and manuring. In speaking of the sprouting of the seed, we have already noticed the requisites for this process, and have pointed out the necessity of attention to the circumstances in which the seed is placed in the soil. Each plant during its growth takes up certain matters from the soil, particularly inorganic substances, as silica and salts of lime, potass, and soda; and some plants take up more of one kind than of another. It is on this principle that the rotation of crops rests, plants being made to succeed each other which require different substances for their nutrition. Now that the chemist and vegetable-physiologist have been called to the aid of agriculture, the farmer is enabled, by an analysis of his crop, of his land, and of his manure, as well as by attention to proper draining and sowing, to carry on his operations in an enlightened manner, and not under the guidance of a blind empiricism.

168. The art of horticulture, too, owes much to the labours of the vegetable-physiologist, as may be seen by the examination of Lindley's able work on the "Theory of Horticulture." The effect of soil and of proper exposure to light and air in the formation of wood and various vegetable products, in giving colour to flowers, and flavour to fruits, are now well ascertained. No one can be a successful gardener who does not act according to the correct principles of botanical science.

169. The improvement of taste in the art of design is not one of the least important applications of botany. "From want of the knowledge of this science, has arisen the anomalies observable in figured patterns, in painted and carved furniture, in paper-hangings, and in dresses. These offend the chastened and classic eye of taste, and the incongruity will leave its impress though the individual be ignorant of botany. It is no uncommon thing to see the flower of one plant combined with the leaves of another, and perhaps associated with the stem of a third; or they may be the sorry creation of a morbid imagination, which sets the laws of harmony at defiance. Crabbe, in his evidence before a Committee of the House of Commons, in relation to the question, expressly assigned this as one of the chief causes of the superiority of our continental neighbours. The French copy diligently from nature, and where can they get finer

forms? Hence the chaste elegance of their patterns, and the superiority of their artificial flowers. Would the rosebud or blossom look so fair and lovely on the stem of a lily as on its native twig? or would the amaryllis appear so graceful if perched on the rose, as it does in nature? There is a harmony and congruity in nature which we would do well to copy. It would correct the taste, and would supply the mind with images alike elegant and graceful."

170. "The real genius in the art of designing," it has been remarked, "does not puzzle his brain to invent strange forms to transfer to the fabric of the loom: he studies nature on the heath, in the field, the hedge-row, the garden, and the conservatory; and endeavours to combine the natural beauties which delight his eye and please his taste. The French designer, so pre-eminent in the beauty of his conceptions and the artistic excellence of his execution, no longer racks his mind for new forms, no longer studies the painted screens of India, or the elaborately ornamented porcelain of China; but flies to the Jardin des Plantes, and watches the development of the buds and foliage of the rare and beautiful plants which are there collected from all parts of the world. And such, too, is rapidly becoming the case in this country. Look at the beautiful forms which are so exquisitely delineated from time to time in the Art-Union, and in our schools of design, and see how very often pure nature is had

recourse to. And to what better school can the artist go? Forms more elegant he cannot invent, colours more beautiful he cannot compound, and the supply thus offered is inexhaustible. The ancients availed themselves of it in all their studies of high art; the pillars of their temples were indebted for their enrichment to the beautiful foliage of plants; the elegance of their domestic utensils is attributable to their nice appreciation of floral beauties. The corollas of the various species of heath, hyacinth, harebell, &c., furnished them with models for their inimitable vases, and amphoræ; and the interior walls of their dwellings were adorned with encaustic paintings, in which groups of flowers or floral borders were of almost constant occurrence. We admire their taste, and have long tried in vain to imitate it, but it is only now that our eyes are becoming opened to the sources from whence they drew their inspirations; and these being discovered, we may now hope for better things. One of the most eminent of French designers, in an article published in the *Art Union*, states that the best of his designs were obtained from the conservatory."

V.—GENERAL REMARKS ON THE PHYSIOGNOMY OF VEGETATION.

171. We have thus endeavoured to lay before

the reader, in a cursory way, the mode in which the science of botany ought to be prosecuted, and some of the advantages to be derived from the study of it. It is a science calculated to give pleasure to every mind. Though relating to living and organized beings, the prosecution of it calls for no cruel experiments, nor for any researches which could excite feelings of disgust even in the most sensitive heart. It is a study which can be turned to account in every situation, whether in the closet or in the field, on the highway or on the hillside, on the cultivated plain or in the wild mountain glen. Every flower on which we tread becomes a useful object of contemplation, and a means of pleasing recreation even amidst the cares and toils of life. The pleasure to be derived from this science is not confined to any period of life, nor to any rank of society. "In youth, when the affections are warm and the imagination vivid; in more advanced life, when sober judgment assumes the reins; in the sunshine of fortune, and the obscurity of poverty, it can be equally enjoyed. The opening buds of spring; the warm, luxuriant blossoms of summer; the yellow bower of autumn; and the leafless, desolate groves of winter, equally afford a supply of mental amusement and gratification to the botanist."

172. To the admirer of natural scenery, plants possess powerful attractions. Without them the

landscape loses all its charms, and their presence gives beauty to objects which would otherwise attract little notice. "Even the miserable hovel becomes picturesque when overspread with the foliage of the vine; the ruins of former magnificence acquire more reverence, and command a double share of our respect, when seen through the tracery of the ivy; and the horrors of the frowning rock are softened into beauty when mantled with pendent creepers, or with alpine shrubs. The ivy-tendril, pendent from the orient window of the ancient ruin, lightly defined in the ray which it excludes, twining with graceful ease round some slender shaft, or woven amid the tracery of the florid arch, contributes in no small degree to give embellishment and interest to the ruin."

173. The love of flowers and of rural scenery is inherent in the constitution of man; and when deprived of the means of gratifying his taste in this respect, we see him adopting various expedients to supply the want.

"What are the casements lined with creeping herbs,
The prouder sashes fronted with a range
Of orange, myrtle, or the fragrant weed,
The Frenchman's darling? Are they not all proofs
That man, immured in cities, still retains
His inborn inextinguishable thirst
Of rural scenes, compensating his loss
By supplemental shifts, the best he may.

. . . .

. . . . There the pitcher stands
A fragment, and the spoutless teapot there:
Sad witnesses how close-pent man regrets
The country; with what ardour he contrives
A *peep* at nature, when he can no more."

174. A garden presents many points of interest, and is associated with some of the most important events which have taken place on the earth. A garden was the habitation of our first parents in their state of innocency. "The Lord God planted a garden eastward in Eden; and there he put the man whom he had formed," telling him "to dress it and keep it."—(Gen. ii. 8, 15.) A garden was the place where Christ often retired with his disciples for meditation and prayer.—(John xvii. 1, 2.) When man yielded to the tempter, it was in a garden. There the curse was pronounced; and there, too, the Redeemer was promised, who was to bruise the head of the serpent.—(Gen. iii. 15.) It was also in a garden where the promised Messiah agonized under the withdrawal of His Father's face, when He was about to be betrayed into the hands of sinners, and to suffer the just for the unjust, that He might bring sinners unto God.—(Matt. xxvi. 36–46.) The similitude of a garden is often used to represent the people of God (Song of Solom. iv. 12, v. 1), who are His husbandry (1 Cor. iii. 9), and the trees of His planting (Isa. lxi. 3.)

175. Flowers form one of the first delights of

early age, and they have proved a source of recreation to the most profound philosophers. Some of the greatest men both of ancient and modern times have been lovers of a garden. When man came forth from the hand of his Maker, a garden was selected as the fittest scene for a life of happiness. With the descriptions given, even by heathen writers, of a state of bliss, gardens have been often associated. The Elysian fields of the polished Greeks and Romans, and the Paradises of other nations, bear witness to this. The emblems and badges of nations and clans are frequently derived from the vegetable kingdom. The poet was crowned with laurel, and peace was marked by the olive branch. The groves of Academus were the resort of the Grecian philosophers; and under the sacred trees of India the benighted heathen worship their idols. Even our cemeteries are converted into gardens, and their gloom is enlivened by the beauteous flowers which blossom around; while the lesson is read, "Man that is born of a woman, is of few days, and full of trouble. He cometh forth like a flower, and is cut down."—(Job xiv. 1, 2.)

176. There is thus a natural taste for the enjoyment to be derived from the vegetation which covers the earth. Would that this taste had always been properly controlled and directed, so as to ensure man's comfort and true happiness!

"Truly God gave us a source of great enjoyment when He made the wild flowers so plentiful, and when He gave them to man as common things. If we wander by the stream, listening to its soft music, there we find them clustering on its surface, or crowding among the verdant sedges and grassy banks through which it flows. White crowfoots lie in patches, and rich blue forget-me-nots peep up among the waters; and the tall yellow-iris waves like a banner; and brooklimes, and water-violets, and water-cresses show their blue, and lilac, and snowy blossoms. On the banks, the yellow flowers of the silver-weed glisten among the grey-green leaves; and the sweet odour of the queen-of-the-meadows is wafted far away over the land, like a sweet strain of melody."

177. We have already attended to the beautiful tints displayed in the colours of flowers, and the skill with which they are arranged; we would now notice the regular succession in which flowers make their appearance, as indicating another wise provision of our Creator. As Cicero remarks, Neque ea uno tempore anni; ut semper et novitate delectemur et copia.—(De. Nat. Deor. ii. 53.) How interesting and instructive to trace the floral productions of the seasons, from the early buds and flowers of spring to the withered stems and the lifeless boughs of winter! How does the voice of spring call us to contemplate the wonder-working Jehovah!

"A few months ago, and the earth was a desert of ice, all was silent and lifeless. The plants were dry and their beauty gone; every where they presented to us only the aspect of death. The trees stripped of their foliage, like dry bones, rattled their bare branches against each other; the brooks and torrents were arrested in their course; their motion was suspended; instead of the breath of life which animates them to-day, the north wind, like the breath of destruction, swept along over that vast cemetery. Who of us, if custom had not rendered us familiar with the prodigies of spring, would not, at the sight of all that death, have been tempted to exclaim, Lord, can all these things live again? And yet what have we seen! From the first days of spring the Almighty has prophesied upon these dry bones; they have appeared to move, to be covered as it were with the nerves of life. Now they live, and they seem to be an exceeding great army to the praise of God. Has not a spirit of resurrection, a living soul entered into nature? Has not the breath of God, from the four winds, breathed upon these dry bones? Each succeeding day these miracles of resurrection increase and spread with as much rapidity as splendour. The whole creation, as if raised from a tomb, is penetrated with life, and pulsates with joy. All these marvels preach to us the truth and certainty of the Divine promises. They repeat, in

a manner most impressive, that the day is coming when the earth, hitherto cursed, shall see rising upon it the sun of an eternal spring."

178. Flowers do not appear all at once, but in orderly rotation. "The snowdrop, foremost of the lovely train, dressed in its robe of innocency, breaks its way through the frozen soil long before the trees have ventured to unfold their leaves, and even while the icicles are pendent on our houses; next peeps out the crocus, but cautiously and with an air of timidity; nor is the violet last in this shining embassy of the year, which, with all the embellishments that would grace a royal garden, condescends to line our hedges, and to grow at the feet of briars. The polyanthus, after adorning the border with its sparkling beauties, gives place to the auricula, with its eye of crystal and robe of the most glossy satin. Tulips then begin to raise themselves on their stately stalks, and adorn the parterre with the gayest colours." In succession appear the anemone, ranunculus, and carnation, to add fresh beauty to the scene. It is in vain to attempt to enumerate the varied flowery forms which succeed each other in the garden. There is an endless multiplicity in their character, yet an invariable order in their approaches. Every month, every week, has its peculiar ornaments; not servilely copying the works of its predecessor, but forming and executing some new design—so

lavish is the fancy, yet so exact is the process of nature.

"Spake full well, in language quaint and olden,
One who dwelleth by the castled Rhine,
When he called the flowers, so blue and golden,
Stars, that in earth's firmament do shine.

Stars they are, wherein we read our history,
As astrologers and seers of eld;
Yet not wrapped about with awful mystery,
Like the burning stars which they beheld.

Wondrous truths, and manifold as wondrous,
God hath written in those stars above;
But not less in the bright flow'rets under us
Stands the revelation of His love.

Bright and glorious is that revelation,
Written all over this great world of ours;
Making evident our own creation,
In these stars of earth,—these golden flowers.

And the poet, faithful and far-seeing,
Sees, alike in stars and flowers, a part
Of the self-same, universal Being,
Which is throbbing in his brain and heart.

Gorgeous flowers in the sunlight shining,
Blossoms flaunting in the eye of day,
Tremulous leaves, with soft and silver lining,
Buds that open only to decay;

Brilliant hopes, all woven in gorgeous tissues,
Flaunting gaily in the golden light;
Large desires, with most uncertain issues,
Tender wishes, blossoming at night!

These in flowers and men are more than seeming;
Workings are they of the self-same Power,
Which the poet, in no idle dreaming,
Seeth in himself and in the flower.

Every where about us are they glowing,
Some, like stars, to tell us Spring is born;
Others, their blue eyes with tears o'erflowing,
Stand, like Ruth, amid the golden corn.

Not alone in Spring's armorial bearing,
 And in Summer's green-emblazoned field,
But in arms of brave old Autumn's wearing,
 In the centre of his brazen shield;

Not alone in meadows and green alleys,
 On the mountain-top, and by the brink
Of sequestered pools in woodland valleys,
 Where the slaves of nature stoop to drink;

Not alone in her vast dome of glory,
 Not on graves of bird and beast alone,
But in old cathedrals, high and hoary,
 On the tombs of heroes, carved in stone;

In the cottage of the rudest peasant,
 In ancestral homes, whose crumbling towers,
Speaking of the Past unto the Present,
 Tell us of the ancient games of flowers.

In all places then, and in all seasons,
 Flowers expand their light and soul-like wings,
Teaching us, by most persuasive reasons,
 How akin they are to human things.

And with childlike, credulous affection,
 We behold their tender buds expand;
Emblems of our own great resurrection,
 Emblems of the bright and better land."

LONGFELLOW.

179. We ought never to forget, that we may look on the broad landscape smiling in summer beauty, and speak with delight of the wonders of nature, and the goodness of a beneficent God, and follow with reverence the man of science as he displays God's wisdom and power in the creation of the universe; and yet there may be no true appreciation of the character of God, no sense of his holiness, and none of that wisdom which cometh from above.—(James iii. 17.) "Where shall wis-

dom be found? or where is the place of understanding? Man knoweth not the price thereof; neither is it found in the land of the living. The depth saith, It is not in me; and the sea saith, It is not with me. It cannot be gotten for gold, neither shall silver be weighed for the price thereof, for the price of wisdom is above rubies. Behold the fear of the Lord, that is wisdom; and to depart from evil is understanding."—(Job xxviii. 12–18, 28.)

180. The study of the economy of vegetation in all its bearings makes the devout mind exclaim in wonder and praise, "O Lord, how manifold are thy works! in wisdom hast thou made them all; the earth is full of thy riches."—(Ps. civ. 24.) "The works of the Lord are great, sought out of them that have pleasure therein."—(Ps. cxi. 2.) The more we examine into all God's ways and doings in providence and grace, the more are we led to see the force of the apostle's statement,—"O the depth of the riches both of the wisdom and knowledge of God! how unsearchable are His judgments, and His way past finding out!"—(Rom. xi. 33.)

"So He ordained, whose way is in the sea,
His path amidst great waters, and His steps
Unknown;—whose judgments are a mighty deep,
Where plummet of archangel's intellect
Could never yet find soundings, but from age
To age let down, drawn up, then thrown again,
With lengthen'd line and added weight, still fails;
And still the cry in Heaven is, 'O the depth!'"

181. The contemplation of God's handiwork, whether displayed in the starry heavens, where He hath set a tabernacle for the sun, or in those stars of the earth—the flowers—should ever, as in the case of the Psalmist, be accompanied by the heartfelt conviction that "The law of the Lord is perfect, converting the soul: the testimony of the Lord is sure, making wise the simple: the statutes of the Lord are right, rejoicing the heart: the commandment of the Lord is pure, enlightening the eyes: the fear of the Lord is clean, enduring for ever: the judgments of the Lord are true and righteous altogether."—(Ps. xix. 7–9.)

INDEX.

EDINBURGH:
PRINTED BY JOHNSTONE AND HUNTER 104 HIGH STREET.